Dr. Theo. M. Trueches.

A
TEXT-BOOK *of* SURGERY

FOR STUDENTS AND PHYSICIANS

By

W. WAYNE BABCOCK

A. M., M. D., F. A. C. S.

Professor of Surgery and of Clinical Surgery in The Temple University;
Surgeon to the Samaritan Hospital and to the American
Hospital for Diseases of the Stomach, Philadelphia;
Chief of the Surgical Service, U. S. General
Hospital No. 6; 1917–1919

WITH 1041 ILLUSTRATIONS
AND 9 PLATES IN COLOR

PHILADELPHIA AND LONDON

W. B. SAUNDERS COMPANY

1929

Copyright, 1928, by W. B. Saunders Company

Reprinted January, 1929

MADE IN U. S. A.

PRESS OF
W. B. SAUNDERS COMPANY
PHILADELPHIA

TO

MY MOTHER

SARAH JANE BUTLER BABCOCK

Digitized by the Internet Archive
in 2024

https://archive.org/details/textbookofsurger0000unse_y7s5

PREFACE

In recent years the teaching of surgery has largely moved from the lecture hall to the bedside and clinic. Students are early brought in contact with the sick patient and are trained in the practice often more than the theory of surgery. The routine of systematic surgical lectures has lost much of its importance. Being early compelled to practice the art of surgery, the student seeks the groundwork in theory and science as well as the details in technic through his reading. The text-book becomes vitalized and the subject becomes a concrete reality bound up with the alleviation of suffering. The requirements of the modern undergraduate parallel those of the practising surgeon and, therefore, a text-book of surgery should supply the needs of both.

For the student particularly, surgery, as nearly as possible, should be presented as a precise, an exact science, but surgery, as with all science, is constantly changing, constantly progressing. How in the face of such evolution can we make it exact and enjoy today's heritage? Only by infinite faith in that heritage. The student or physician who reasons "why learn today what tomorrow may prove wrong? Why strive for exactness when the most learned are often in error?" not only loses his usefulness in a progressive profession, but lays down the torch of progress bequeathed to him. I have, therefore, written in a dogmatic vein what practice and study have made me believe is true today. If tomorrow I progress to an opposing point of view I shall not lose faith. I shall still be dogmatic. Yesterday an intestinal anastomosis was best done by the Murphy button; amputation at the hip-joint required Wyeth's pins; and a craniotomy, a trephine. As we progress we lay aside these aids of previous days with grateful reverence, not with apology or disdain. We shall not scorn what was done yesterday because we have something better today any more than our interest in the past will cause us to continue the practice of the past. No longer do we think in terms of molecules and atoms, nor do we continue to irrigate for peritonitis, curette for streptococcal infection, or treat a gunshot wound without tetanus antitoxin. Today we have new standards and responsibilities, and the lives of many patients depend on their enforcement. A text-book especially should standardize approved practice.

By standardization earlier diagnoses are made. Yesterday it was excusable to diagnose appendicitis by peritonitis; a gastric ulcer by hemorrhage or perforation; a cancer of the stomach by cachexia, epigastric mass, and hypochlorhydria. Today we do not tolerate delay for such terminal complications. By standardization of essential symptoms diagnoses formerly thought beyond the range of common medical knowledge are made by the practitioner remote from medical centers. A spinal tumor, pancreatitis, or a pulmonary abscess is recognized by an interne.

By adherence to standards in treatment morbidity is lowered. Five centimeters of shortening after fracture of the femur now requires explanation, a Volkmann contracture carries a disabling brand to the surgeon as well as to the patient, and mutilating or crippling scars mar the reputation of the physician as well as the body of the patient. Yesterday the surgeon could consider his own convenience provided the life of the patient was not ignored. Today he must accept the more difficult task and, as far as possible, conserve not only the life, but the function, appearance, and comfort of the patient. The day of the surgeon aptly described by Crile as carnivorous, who crushed and tore his way through the tissues, has passed. Artistry, delicacy, and finesse combine with respect for function.

By standardized practice lives are saved. No longer should patients die from appendicitis because they are fed and purged; or from prostatic obstruction because of lack of preparatory treatment; or from anthrax because the lesion is traumatized. Such dangerous forms of practice, many of which remain as traditions, should be expurgated.

The nomenclature of the student should not be changed in his surgical course. It should conform to that taught in his earlier years. The terms used in Gray, Morris, Cunningham, and Spalteholz have, therefore, been adopted. For those not familiar with the Basle nomenclature the old terms have been added in brackets.

Subjects bound up with surgery, but taught in cognate departments have been epitomized. Highly developed specialties in regional surgery, such as ophthalmology, otorhinology, gynecology, which have outgrown the confines of a treatise on surgery have been omitted. Orthopedic surgery, proctology, urology, and venereal diseases have been included. I have tried to omit the controversial, purely theoretical, and obsolete except as they may be instructive or have historic interest.

A text-book is of value if it wisely correlates and systematizes the advanced practice of the time. It expresses the author's reaction to the past and especially to the present. Even in originality he cannot dissociate the influence of his preceptors and authors. It is not always easy to give rightful credit when the contributors to the science form such a multitude. Nevertheless, the many names incorporated and the associated dates will aid those who seek the original contributions. The text has been visualized by the art of Mr. McNett in accord with the best traditions of the Max Brödel school. I am indebted to Mrs. B. A. Baumann for most of the clerical work, to Mr. Franklin Christopher for the Index, and to the staff of the W. B. Saunders Company for unfailing courtesy and efficiency.

W. Wayne Babcock.

1720 Spruce Street.
Philadelphia, Pa.

CONTENTS

PART I. GENERAL SURGERY

CHAPTER I

PAGE

General Considerations 17

CHAPTER II

Inflammation and Repair 20

CHAPTER III

Wounds; Injuries and Diseases Received from Lower Animals 36

CHAPTER IV

Burns and Scalds; War-gas Poisoning; Effects of Cold 66

CHAPTER V

Hemorrhage, Hemostasis, Transfusion 77

CHAPTER VI

Thrombosis and Embolism 94

CHAPTER VII

Necrosis and Gangrene 100

CHAPTER VIII

Shock 112

CHAPTER IX

Coma and Delirium 118

CHAPTER X

Infection and Disinfection 125

CHAPTER XI

The Acute Surgical Infections 141

CHAPTER XII

The Chronic Surgical Infections—The Specific Granulomas 158

CHAPTER XIII

Tumors and Cysts 181

PART II. THE SURGERY OF SYSTEMS

CHAPTER XIV

PAGE

The Bones 223

CHAPTER XV

Fractures 255

CHAPTER XVI

The Joints 329

CHAPTER XVII

Dislocations 346

CHAPTER XVIII

The Muscles, Tendons, and Bursæ 381

CHAPTER XIX

The Blood-vessels 391

CHAPTER XX

The Lymphatics 419

CHAPTER XXI

The Peripheral Nerves 429

CHAPTER XXII

The Skin and Cutaneous Appendages 460

CHAPTER XXIII

The Ductless Glands 475

PART III. SURGICAL TECHNIC

CHAPTER XXIV

Surgical Therapeutics 500

CHAPTER XXV

Bandaging 520

CHAPTER XXVI

General Anesthesia 533

CHAPTER XXVII

Regional Anesthesia 554

CHAPTER XXVIII

The Operation. Pre- and Post-operative Treatment 580

CHAPTER XXIX

PAGE

Operative and Plastic Surgery 595

CHAPTER XXX

Ligations 622

CHAPTER XXXI

Amputations 641

PART IV. REGIONAL SURGERY

CHAPTER XXXII

The Scalp and Skull 664

CHAPTER XXXIII

The Meninges and Brain 687

CHAPTER XXXIV

The Cranial Nerves 725

CHAPTER XXXV

The Spine and Cord 738

CHAPTER XXXVI

The Face 784

CHAPTER XXXVII

The Jaws 805

CHAPTER XXXVIII

The Mouth, Tongue, and Salivary Glands 818

CHAPTER XXXIX

The Pharynx, Larynx, and Trachea 830

CHAPTER XL

The Neck 845

CHAPTER XLI

The Esophagus 860

CHAPTER XLII

The Thoracic Wall 872

CHAPTER XLIII

The Mammary Gland 888

CHAPTER XLIV

The Pleura 912

CHAPTER XLV PAGE

The Lungs 923

CHAPTER XLVI

The Heart and Aorta 943

CHAPTER XLVII

The Abdominal Wall 953

CHAPTER XLVIII

The Peritoneum 975

CHAPTER XLIX

The Stomach and Duodenum 998

CHAPTER L

The Small and Large Intestine 1053

CHAPTER LI

The Vermiform Appendix 1095

CHAPTER LII

The Liver and Biliary System 1119

CHAPTER LIII

The Pancreas 1150

CHAPTER LIV

The Spleen 1157

CHAPTER LV

Hernia 1165

CHAPTER LVI

The Rectum and Anus 1206

CHAPTER LVII

The Genito-urinary Organs 1222

CHAPTER LVIII

The Extremities 1288

INDEX 1313

A Text-Book of Surgery

Part I

GENERAL SURGERY

CHAPTER I

GENERAL CONSIDERATIONS

The healing art is divided into "*Internal Medicine*" and "*External Medicine*" or *Surgery*. *Internal Medicine* is the study of disease in relation to its prevention, alleviation, or cure by indirect measure, including hygiene, diet, exercise, drugs, vaccines, and antitoxins. *External Medicine* or *Surgery* is the study of such diseases as may be directly treated by the application of physical force, chemical substance, or drug to the abnormal part.

Internal medicine and surgery are so closely interrelated that there is no sharp line of division. Either may consider treatment by direct or by indirect measures. Both require knowledge of embryology, phylogeny, ontology, anatomy, physiology, parasitology, pathology, and the related sciences of physics, chemistry, pharmacy, materia medica, and psychology. It is the province of internal medicine to cover the broad subject of disease. Surgery is concerned with the direct attack upon accessible lesions.

Surgery (*Chirurgery*—Greek χείρ hand, ἔργον work), therefore, is that branch of medicine which deals with diseases requiring treatment by direct methods. It should be emphasized that operative surgery is but a part of the subject. The *science* of surgery is the adaptation of the various medical and related sciences to the solving of surgical problems. The *art* of surgery is the practical use of physical or chemical measures in the treatment of disease. It deals with the technical application of the science of surgery. A scientific surgeon may have little art, his incisions may be crude, his manipulations bungling, yet his results may be saved by his scientific knowledge. A highly skilled surgeon may show great art, yet fail from lack of scientific knowledge or common-sense application. His brilliantly performed operation may be unnecessary, unwisely selected, or untimed for the particular condition. Although his incision be artistically made and closed, the operation, as a whole, may be poor because anatomic or physiologic factors were not known or considered.

Surgical art, by speed and facility in operating, may be spectacular and brilliant, as in the case of Ferguson or Joseph Pancoast; or by meticulous attention to science and detail, although time consuming and without dash, be

of the highest order, as in the case of Kocher or Halsted. Speedy, spectacular, thrillingly dextrous operative work can never compensate for a lack of science in surgery. The highest art is the protection of the patient and of his tissues. This is shown by the selection of the best procedure that the patient can then endure, by delicacy and skill in manipulation of the tissues, by the absence of bruising, crushing, or laceration, by the conservation of blood and body heat, by the protection of nerves, blood-vessels, and other important structures, and by the avoidance of strangulating constriction in the closing of wounds. Embracing and guiding all science and skill there must be an uprightness of character that will lift an honorable profession far above the sphere of commerce and trade. A surgeon will ever first be actuated by the welfare of his patient. He will study to protect those entrusted to his care from unnecessary operation or mutilation. He will accept the greater difficulty and burden in his work if it is for the welfare of those he serves. He will esteem relief from suffering and disability as his greatest reward. He will not degrade himself or his calling by offering gratuity or commission for patients, or by bartering with those who would commercialize medicine.

General surgery deals with conditions involving all or any part of the body, and is the science of surgery without respect to site.

Special or *regional surgery* is surgery considered in relation to a particular region or part of the body. This, in turn, is divided, according to the area considered, into: *Cranial surgery; oral surgery; dento-facial surgery; orificial surgery; pelvic* or *gynecologic surgery; genito-urinary* or *urologic surgery; rectal* or *proctologic surgery; obstetric surgery,* and *arthrosteopedic surgery.*

Surgery is also divided, according to conditions influencing the surgical procedure, into: *Military surgery,* concerned with the injuries of war; *industrial surgery; railway surgery,* that related to railway injuries; *plastic surgery,* the correction of defects by the transfer of tissue; *orthopedic surgery,* the correction of deformities, especially of the bones, joints, and extremities, and *featural, cosmetic,* or *decorative surgery.*

Operative surgery deals with the formal mechanical or operative procedures. It includes *dry* or *bloodless surgery,* in which the necessary manipulations are carried on without division of the skin, and *wet* or *bloody surgery,* in which the necessary manipulations require division of the skin or other tissue.

Major surgery considers the more important and dangerous operations involving a distinct risk of life. *Minor surgery* covers the smaller and less formidable procedures, such as bandaging, the application of splints and dressings, intravenous and subcutaneous injections, the opening of abscesses, and the like.

Clinical surgery refers to the practical application of surgical procedures at the bedside or in the clinic.

Experimental surgery is devoted to the solving of surgical problems, usually in the laboratory.

Surgical measures are: *Diagnostic,* revealing pathologic changes during life; *reconstructive,* restoring or replacing parts defective or abnormal from development, injury, or disease; *evacuant,* giving exit to abnormal collections, and *ablative,* removing parts no longer of use to the body.

Surgical Eras.—An attempt has been made by Robert Morris to show that surgery has evolved through three periods. In the first or *pathologic era*, the guiding principle was the removal of pathologic conditions or products, as the evacuation of abscesses, the removal of calculi, the excision of tumors, and the amputation of diseased or damaged parts. In the second or *anatomic era*, surgeons were largely concerned with the restoration of structure. In the present or so-called *physiologic era*, the restoration of function is considered as the highest aim of the surgeon.

In this treatise, as far as is practicable, the surgery of each part of the body is unfolded upon the following systematic plan:

(a) Congenital malformations and anomalies.
(b) Anemias, hyperemias, hypertrophies, and atrophies.
(c) Traumatic injuries.
(d) Inflammations: acute, subacute, chronic, and of special origin.
(e) Parasitic affections.
(f) Neoplasms.
(g) Special operations.

As far as the importance of the subject warrants the description of each condition is systematized under the following heads:

(a) Synonyms.
(b) Definition.
(c) Etiology, including heredity, age, sex, race, occupation, and traumatism.
(d) Pathology.
(e) Symptomatology.
(f) Diagnosis.
(g) Prognosis.
(h) Treatment, including: (1) *Medical treatment:* a brief synopsis of the dietetic, hygienic, physical, and pharmaceutic measures, including heat, light, electricity, other forms of radiant energy, and the use of drugs. (2) *Operative treatment:* indications, contraindications, mortality, morbidity, and technic.

CHAPTER II

INFLAMMATION AND REPAIR

Inflammation is the protective reaction of living tissues against the action of irritants.

Pathology.—The inflammatory reaction of the tissues to irritation is shown by: (1) *Vascular changes.* There is transient contraction, followed by wide dilatation of blood-vessels, with an acceleration, followed by slowing of the blood current. The leukocytes drift with abnormal slowness into contact with the vessel wall, adhere, and transmigrate into the surrounding tissues from positive chemotaxis. Exudation of serum occurs, followed finally in intense inflammation by diapedesis of erythrocytes from intravascular pressure and the alteration in the blood-vessel walls. (2) *Lymphatic changes* are marked by distention of the lymph-vessels, spaces, and nodes by liquid and cellular transudate. (3) *Cell multiplication*, and (4) *malnutrition*, with degeneration and necrosis of the tissue cells.

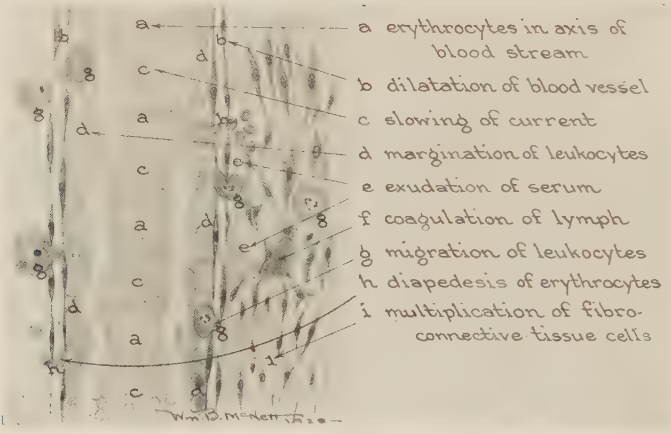

a erythrocytes in axis of blood stream
b dilatation of blood vessel
c slowing of current
d margination of leukocytes
e exudation of serum
f coagulation of lymph
g migration of leukocytes
h diapedesis of erythrocytes
i multiplication of fibro-connective tissue cells

Fig. 1.—Pathologic changes in acute inflammation. Section of a blood-vessel and adjacent tissues. (Semidiagrammatic.)

Inflammatory Products or Exudates.—(1) *Serous exudate*—the serum exuded in inflammation—contains more leukocytes and albumin, and has a higher specific gravity than a transudate or dropsical fluid. (2) *Fibrinous, croupous*, or *diphtheritic exudate* occurs from the coagulation of the liquid exudate. The bacteria may supply the fibrin ferment as occurs in diphtheria and pneumonia. (3) *Hemorrhagic exudate* contains erythrocytes from injury of the blood-vessel walls. (4) *Corpuscular exudate* contains many leukocytes. This is termed "cellular exudation" or "round-celled infiltration" when mild; or "purulent exudation" or "suppuration" when marked.

Classification.—A. *Surface inflammations* include: (1) *Vesicular*, marked by circumscribed elevations containing serous exudate (*vesicles, blisters* or, if large, *bullæ*. (2) *Pustular*, with circumscribed elevations containing pus (*pustules*). (3) *Catarrhal*, when occurring upon a mucous surface, characterized by liquid discharge. It may be mucoid (*mucous catarrh*), mucopurulent (*mucopurulent catarrh*), or purulent (*purulent catarrh*). (4) *Desquamative*, characterized by a marked shedding of the superficial cells. (5) *Diphtheritic* or *croupous*, characterized by a fibrinous exudate or false membrane. (6) *Ulcerative*, an inflammatory process on a surface with loss of substance.

B. *Inflammations of organs* include: (1) *Catarrhal inflammations*, chiefly affecting the ducts of the organ, with an excessive or abnormal discharge. (2) *Parenchymatous inflammations*, especially involving the essential cells of the organ. (3) *Interstitial inflammations*, showing a predominant involvement of the supporting connective tissue of the organ. (4) *Degenerative inflammations*, characterized by a rapid parenchymatous destruction.

Exudative inflammations are those with exudation; *adhesive* or *agglutinative*, those with adhesions; *gangrenous*, with gangrene; *specific*, when due to definite bacteria; *phlegmonous*, when due to purulent infiltration of the areolar tissues; *productive*, when leading to the formation of new tissue.

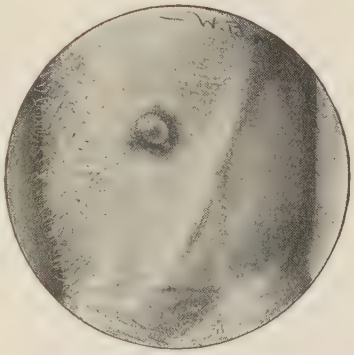


Fig. 2.—Vesicle.

As to Duration.—(1) *Acute inflammations* are characterized by rapid onset, destructive lesions, and short course. (2) *Subacute inflammations* have an onset that is more gradual, lesions that are less destructive, and a longer course. (3) *Chronic inflammations* are characterized by gradual onset, progressive and often productive lesions, an unlimited course, or one that may continue for weeks, months, or years.

Dominant or Characteristic Lesion.—(1) Acute interstitial inflammation is *round-celled infiltration* or *abscess formation;* (2) chronic interstitial inflammation, a connective-tissue proliferation, *fibrosis, scirrhosis*, or *cirrhosis;* (3) acute parenchymatous inflammation, *cloudy swelling;* or (4) chronic parenchymatous inflammation, *fatty degeneration*. The infiltration of round cells, largely polymorphonuclear leukocytes, is the most characteristic feature of inflammation.

The inflammatory products cause a variety of lesions. A serous exudate under the epidermis of skin produces *vesicles* or *bullæ;* in interstitial tissues, an *inflammatory edema;* on mucous surfaces, a *catarrh;* in serous cavities, a *hydrothorax* or *serous pleurisy, hydroperitoneum* or *serous peritonitis, serous arthritis, serous distention of bursæ*, or *serous bursitis*.

Etiology of Inflammation.—*Irritants* causing inflammation may be: *Mechanical*, as traumatic injury; *physical*, as heat, cold, light, electricity, Roentgen rays, radium; *toxic*, as chemicals, drugs, metabolic products of bacteria or of the tissues. Pathogenic bacteria are the chief exciting factors in inflammation. Impaired tissue resistance resulting from heredity, circulatory

change, trophic influence, or any of the above causes may predispose to inflammation by bacterial invasion.

Extension of inflammation occurs: (1) *Along surfaces*, as the skin, or mucous or serous membranes; (2) *along natural channels*, as the lymphatics and blood-vessels, or planes of tissue separation, as along fasciæ and aponeuroses; (3) *by contiguity*, or extension to contiguous or adjacent structures; (4) *by metastasis*, where the cause of inflammation is carried to a distant point by the circulation of blood or lymph.

Terminations.—1. *Recovery:* The fluid exudate is removed through the lymphatics, while the leukocytes and other cells aid in the disintegration and removal of solid particles. The injury to the tissues may be repaired by (a) *regeneration* of tissue of the same type, or (b) *replacement by fibroconnective* tissue.

2. *Suppuration, Necrosis, Gangrene:* The retained dead material (*sphacelus, sequestrum*) may cause a continuance of the inflammatory action.

3. *Isolation of the source of irritation*, usually by the formation of a connective-tissue capsule about it.

4. *Hyperplasia*, usually of connective-tissue elements (*productive inflammation*). By subsequent contraction and pressure of the newly formed connective tissue and the obliteration of the new vessels atrophy and degeneration of the parenchyma of organs may result, or marked deformity be produced.

Symptoms.—The classical symptoms of inflammation are: *dolor, calor, rubor, tumor et functio læsa*, or pain, heat, redness, swelling, and disordered function.

Pain results from the pressure of exudate upon the nerves and nerve endings, and the irritation from bacterial or tissue products, foreign bodies, or chemical substances; *heat*, from the increased circulation and chemical changes in the tissues. *Redness* is caused by the hyperemia and dilatation of blood-vessels; *swelling*, by the exudate in the tissues and the distention of vessels.

Pain is a distressing, subjective, sensory impression registered by the cerebral cortex from peripheral irritation. Tenderness is pain elicited by pressure. Pain is produced by irritation of peripheral, sensory nerves or nerve-roots. From irritation of the posterior spinal nerve-roots, darting, lancinating, electric shock-like pain is produced. The brain and cord proper are insensitive, as are the lungs, liver, stomach, and intestines. Excessive peristalsis of the stomach is accompanied by a sense of pressure, burning, or gnawing, often associated with nausea and vomiting; of the intestine, *tormina*, cramp-like pains or belly-ache; of the rectum, bladder, or urethra, *tenesmus*, which is characterized by straining and pressure in the effort to empty the viscus. Traction upon the omentum causes epigastric distress and nausea. The skin of the fingers and toes, particularly about the matrices of the nails and on the palmar surface of the fingers, is much more sensitive than the scalp or back. Inflammation of the skin is expressed by itching, formication, burning, or stinging. Normal bone is but slightly sensitive; when inflamed or irritated, the pain is dull, aching or boring, and is more intense at night. Inflammations of the pleura or peritoneum cause pain of a sharp, cutting, or stabbing character; of the meninges, headache or cephalgia; of the nerve-trunks, of a tingling, boring, lancinating, darting, stabbing type.

The formation of pus is characterized by throbbing, or a painful sense of pulsation in the part. With the pointing of pus, the pain becomes darting and lancinating.

General Reaction in Inflammation.—(1) A *chill* or *rigor:* due to the intravascular entrance of toxic material. It may be produced experimentally or therapeutically, as in protein shock, by injecting a minute quantity of bacterial toxin or sterile animal protein (milk) into the blood-vessels. A severe chill

follows this method of administration, but often does not occur when the toxic material is introduced subcutaneously or intramuscularly. (2) *Fever:* An increase in the temperature of the body, usually associated with increased pulse and respiratory rate, leukocytosis, and increased metabolism. (3) *Impairment* or *stimulation of organic function.*

Prognosis in inflammation depends upon the character of the irritant and the efficiency of the tissue resistance.

Treatment.—1. **Acute Inflammation:** (a) *General treatment* includes rest with recumbency, elimination, baths, laxatives, enemas, fresh air, sunlight, sera and vaccines, and in general the avoidance of local or general stimulation. An artificial leukocytosis by the injection of nuclein, other protein, or turpentine is at times desirable. (b) *Local treatment* includes rest, elevation, moist heat, dry heat; hyperemia, active or passive (Bier's treatment); incision or excision of the affected tissue.

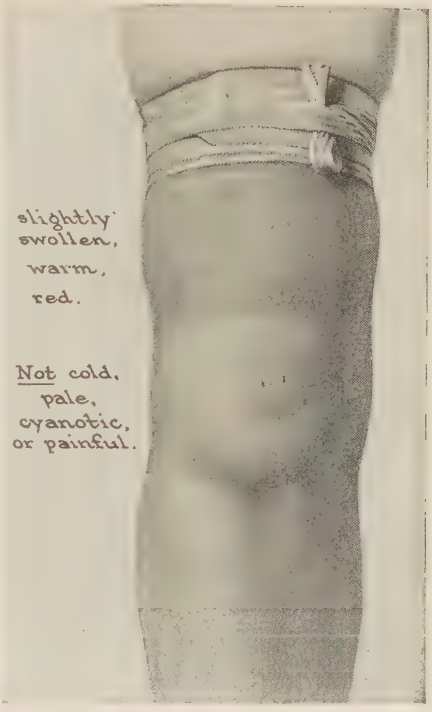


Fig. 3.—Bier's passive hyperemia by an elastic band.

2. **Chronic Inflammation.**—(a) *General Treatment:* Vaccines and specific remedies are often of greater value than in acute inflammation, and attention to the general health and resistance is especially important. (b) *Local treatment* consists largely in improving the circulation in the part and in stimulating the cellular changes.

Active hyperemia is produced by heat generated in various ways: (1) The affected part is introduced into a *dry-air oven,* heated by electricity, gas or other agent, and the temperature gradually raised to 180°, 200°, 300° F. or more. The arteries and capillaries dilate, perspiration escapes in quantity, and by evaporation prevents the tissues from being burned. Increased loss of water from the body produces thirst, and the patient is permitted to drink liquids freely. The baking is continued for from ten minutes to an hour. To prevent burns the body should be carefully insulated from any metallic part of the oven.

(2) *Infra-red Light.*—Electric lamps or coils giving off heat-rays are used, to the action of which the affected part of the body is exposed.

(3) *Quartz* and *carbon arc* electric lights, in which the action of heat is combined with ultraviolet and other light rays, are useful in producing active hyperemia. The rays also produce dermatitis and pigmentation of the skin as in sunburn.

(4) *Diathermy* causes an increase in temperature of the deeper tissues.

Passive hyperemia (Bier's treatment) is used for acute, subacute, and

chronic inflammatory processes and is characterized by the production of venous congestion in the affected part. For an extremity, an elastic band of rubber is placed about the part, with sufficient tension to partially interrupt the venous return but not the arterial inflow. For the head the band is placed about the neck. The part distal to the band should become warm, red, slightly swollen, and painless; pain, pallor, cyanosis, coldness, or edema indicates that the tension is too great, and the band should be readjusted. For the trunk or other parts of the body that cannot well be constricted by a band, large and small glass cups are applied, from which the air is partially exhausted by a rubber bulb or other device, giving the effect of cupping-glasses under light tension.

Counterirritation produced by means of iodin, mercurials, or other rubefacients, a blister or cautery is often useful for deep subacute or chronic inflammations.

Fig. 4.—Passive hyperemia produced by Bier s cupping-glass.

Roentgen ray, used with great care, is beneficial in certain specific chronic granulomas, as tuberculosis and actinomycosis.

Repair or Regeneration.—The power of regeneration of tissues after destruction is inversely as the specialization of the tissue destroyed and as the space to be filled. The more highly specialized tissues have but limited regenerative ability, and any considerable tissue destruction is repaired by replacement with fibroconnective tissue. The reparative formation of fibroconnective tissue and epithelium is termed *cicatrization*, and results in the formation of a *cicatrix* or *scar*. Regenerated tissue is always derived from tissue of the same blastodermic type; large masses that are lost, as by amputation, are not replaced.

Cicatrization.—The lymph exuded from the blood-vessels coagulates, and is invaded by leukocytes from the blood-vessels and by proliferating fibroblasts. Narrow cellular buds, formed by proliferation of the capillary endothelium, project from the capillaries into the area and become tunneled into capillary

vessels. Fibroblasts nourished by the newly formed vessels, and possibly also by the disintegrating leukocytes, become spindle shaped and are finally converted into connective-tissue fibrils. The leukocytes apparently aid the process by a phagocyte and scavenger-cell action.

Formative fibroconnective tissue, consisting chiefly of newly formed capillaries, fibroblasts, and leukocytes, is termed "granulation tissue." Minute, rounded capillary loops (*granulations*), forming a red and vascular papillary layer, project from the affected surface, are surrounded by leukocytes and fibroblasts, and by the formation of superimposed granulations gradually fill the defect.

Epithelization.—After the granulations reach the level of the surrounding epithelium, should an epithelial surface be involved, the adjacent epithelial cells proliferate, and gradually spread from the edges of the defect over the

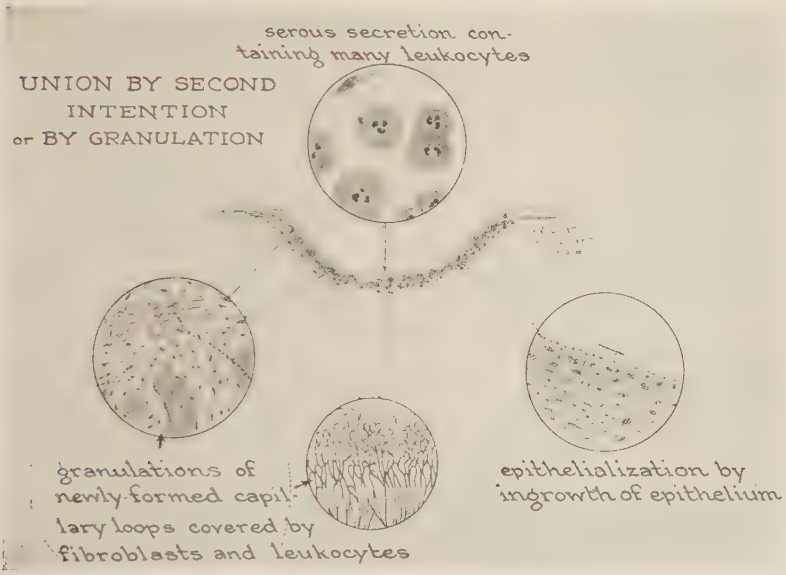

serous secretion containing many leukocytes
UNION BY SECOND INTENTION or BY GRANULATION
granulations of newly-formed capillary loops covered by fibroblasts and leukocytes
epithelialization by ingrowth of epithelium

Fig. 5.—Granulation and epithelization illustrated in a wound healing by second intention. (Semidiagrammatic.)

granulating surface. In the meantime the deeper granulations become more fibrous and markedly contract, greatly narrowing the defect that is to be filled. Scars, at first red, tend in time, therefore, to become pale and to contract, with obliteration of many of the new blood-vessels and cells and the transformation of the cells into connective-tissue fibrils, so that finally a dense fibrous scar is formed.

Regeneration of other varieties of connective tissue resembles regeneration of fibroconnective tissue. In bone and cartilage the formative cells are termed, respectively, "osteoblasts" and "chondroblasts." In bone formation there is calcareous infiltration; in adipose tissue, fatty infiltration.

Character of Cells.—(1) *Leukocytes* are derived from blood or lymphatics, and are small cells with deeply staining and usually polymorphic nuclei. They serve as scavengers and phagocytes, and do not form tissue. (2) *Fibroblasts,*

epithelioid cells, are formed by the proliferation of pre-existing connective tissue. They have a rather pale staining, rounded or oval nucleus, and are larger and have more protoplasm than leukocytes. Their function is the formation of connective-tissue fibrils. (3) *Plasma-cells*, stained with Unna's polychrome methylene-blue show pale cubic or rhombic nuclei, eccentrically placed, while the protoplasm of the cell periphery shows deep-staining, ball-like masses. Plasma-cells are amebcid and appear to be able to form connective tissue. (4) *Mast-cells* are large cells with pale staining, trilobed nuclei, and many coarse basophilic granules. They are found in areas of chronic inflammation and of mucoid degeneration. (5) *Giant-cells* are cellular monstrosities, produced by fusion of epithelioid cells or nuclear multiplication without cellular division. They are normally found in placenta and in bone-marrow, and also occur about embedded foreign bodies, in very chronic inflammatory processes, in some of the specific granulomas, in tuberculosis, syphilis, actinomycosis, and in certain tumors, especially the giant-celled tumor of bone and certain sarcomas.

Regeneration of More Highly Specialized Tissues.—*Striped muscle* is regenerated by nuclear division and budding of sarcoplasm. Fibroconnective tissue may first form and be later replaced by muscle-fibers. A limited regeneration of *unstriped muscle* occurs from nuclear division. The *liver* shows marked ability to regenerate. Over one-half of the removed liver will regenerate in lower animals after excision. The *kidney* has probably a less marked ability to regenerate. *Nerve* lesions are repaired by fibroconnective tissue, which may later be traversed by proliferated axis-cylinders that in time acquire myelin sheaths. Ganglionic nerve-cells and non-medullated nerves are not regenerated.

Suppuration is the formation of pus.

Pus is an opaque, yellowish, alkaline, liquid inflammatory exudate composed of *pus-corpuscles*, which are chiefly living or dead polymorphonuclear leukocytes, and *pus-serum* or *liquor puris*. Peptone and tissue detritus are usually associated. *Seropus*, *mucopus*, and *sanious pus* refer respectively to admixtures with serum, mucus, or blood. Pus may be creamy, curdy or cheesy, or ichorous (thin and acrid). The puriform fluid found in degenerating tumors and many cold abscesses from tissue necrosis and liquefaction, but not containing large numbers of pus-corpuscles, is not true pus.

Pus may be: (1) *sterile*, (2) *infectious* or *septic*, (3) *living* or *dead*.

Living pus—the *laudable pus* of the older writers—contains many living phagocytic cells in a more or less protective liquid, and may be *sterile*. It has bactericidal, bacteristatic, phagocytic, bacteriolytic, and antitoxic properties. In the peritoneal cavity it is very valuable in protecting the body against bacterial invasion, and in the destruction and neutralization of bacteria and their products. Its antiseptic qualities are impaired by dilution and the addition of antiseptics.

Phagocytosis is produced by two types of phagocytes: (1) Microphages or polymorphonuclear leukocytes, and (2) the macrophages, including the larger mononuclear leukocytes, the endothelial cells, and connective-tissue cells. Ferments produced by the leukocytes (opsonins or alexins) prepare the bacteria for destruction by the phagocytes. In the production of immunity there is a reaction between the specific virus or antigen and the tissues; the reaction of the tissues to the virus or antigen helps in the production of antibodies (including antitoxins) and bacteriolysis. Antitoxic serums and antibacterial serums are protective respectively against the toxins or the bacteria.

Dead pus contains dead cells, has lost most of its protective character, and is often infectious. Like other dead tissue elements, it should be removed from the body as soon as possible. *Septic pus* contains living pathogenic organisms and bacterial toxins that the pus-cells or pus-serum have been unable to destroy or neutralize. It should be removed from the body.

Etiology of Suppuration.—(1) The pyogenic bacteria, especially the Staphylococcus albus and aureus, the Streptococcus pyogenes, the Bacillus pyocyaneus, Bacillus typhosus, Bacillus coli communis, the gonococcus, the pneumococcus, Diplococcus intracellularis meningitidis, and others. (2) Experimentally, aseptic suppuration has been produced by croton oil, turpentine, calomel, and other irritating drugs.

Abscess is a circumscribed collection of pus in the tissues. The term *pyogenic membrane* is improperly applied to the inflammatory, degenerative, or reparative zone limiting the abscess.

Varieties.—(1) *Acute* or *hot* abscess, with active inflammatory symptoms. (2) *Chronic* or *cold* abscess, without active inflammatory symptoms, usually due to necrosis or tuberculosis, and containing, as a rule, an excess of mononuclear rather than polymorphonuclear leukocytes. (3) *Embolic*, due to septic embolus. (4) *Pyemic* or *metastatic*, multiple abscesses from circulating pyogenic organisms.

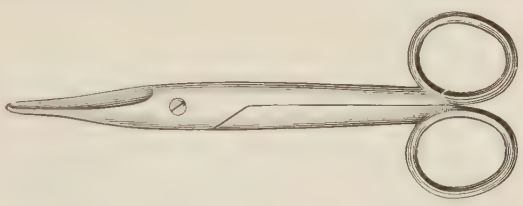


Fig. 6.—Mayo dissecting scissors. Useful in opening deep abscesses by Hilton's method.

Termination.—The abscess may: (1) *Point, evacuate*, and the pus be discharged, or (2) be *retained*, the pus becoming inspissated, curdy, encapsulated, and at times being absorbed. *Pointing* refers to the movement of abscesses, which is usually from the source of blood-supply and in the direction of least resistance. The *movement* or burrowing results from (a) the pressure of surrounding tissue; (b) the interference with tissue nutrition by mechanical pressure, vascular or lymphatic obstruction, or toxic influences; (c) the macerative and digestive action of the pus aided, at times, by the absorptive action of the stimulated tissue-cells. When the abscess reaches a surface, an elevation appears which becomes necrotic and yellow (*pointing*), and gives way with evacuation and discharge of the pus.

Phlegmon is a diffusion of pus through the areolar tissues. *Empyema* is a collection of pus in one of the body cavities, as the pleura (*Pyothorax, Purulent pleurisy*); pericardium (*Pyopericardium*); a joint (*Pyarthrosis*); or the gall-bladder (*Purulent cholecystitis*).

Treatment.—Acute abscesses and phlegmons should be treated by an early incision, free drainage, and wet or moist dressing. In opening deep abscesses *Hilton's method* is often used to avoid injury to blood-vessels or other important structures. An incision is made through the skin, a pointed forceps

or Mayo scissors inserted to the abscess, the blades opened, and withdrawn in the open position.

Ulceration, Ulcer.—An open wound or sore. An inflammatory lesion of the surface of the body with loss of substance.

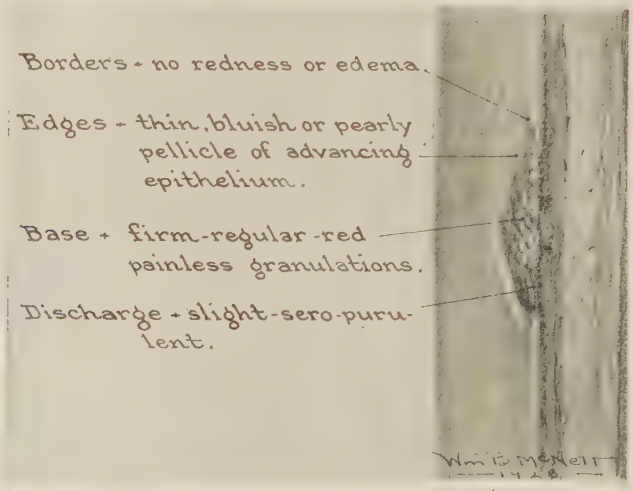

Borders - no redness or edema.
Edges - thin, bluish or pearly pellicle of advancing epithelium.
Base - firm-regular-red painless granulations.
Discharge - slight-sero-purulent.

Fig. 7.—Healing ulcer, or union by second intention.

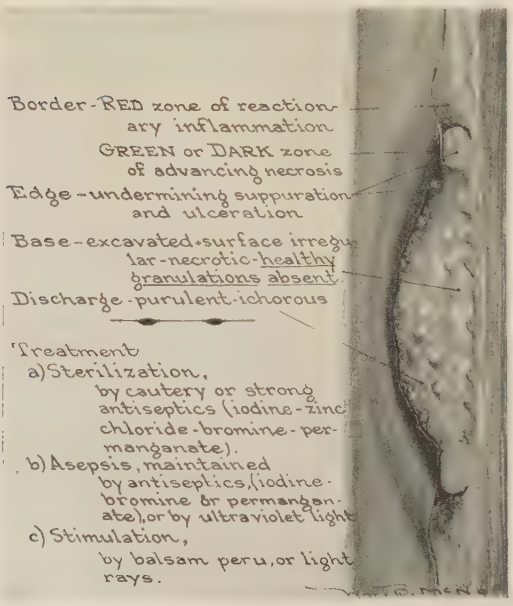

Border - RED zone of reactionary inflammation
GREEN or DARK zone of advancing necrosis
Edge - undermining suppuration and ulceration
Base - excavated - surface irregular - necrotic - healthy granulations absent
Discharge - purulent - ichorous
Treatment
a) Sterilization, by cautery or strong antiseptics (iodine - zinc chloride - bromine - permanganate).
b) Asepsis, maintained by antiseptics, (iodine - bromine or permanganate), or by ultraviolet light
c) Stimulation, by balsam peru, or light rays.

Fig. 8.—Phagedenic ulcer.

Classification.—(1) *As to cause:* traumatic, septic, varicose, peptic, or from heat, cold, Roentgen-rays, or other form of radiant energy. (2) *As to constitutional condition:* gouty, diabetic, syphilitic. (3) *As to local condition:* healing, spreading, weak, inflamed, varicose, callous, indurated, indolent, irritable, phagedenic, malignant, carcinomatous, epitheliomatous.

Pathology.—The ulcer presents: (1) A *base* or floor, which may be depressed, smooth, irregular, craggy, crateriform, granulating, sloughing, indurated. (2) *Discharge*, including a purulent, serous, hemorrhagic, curdy, ichorous, or odorous discharge. (3) *Edges* or margins, which vary in shape, being rounded, oval, circinate, dentate, serpiginous, irregular, sloping, overlapping, undermined, punched out, everted, rolled, thickened, indurated, or depressed. The *surrounding tissues* may be congested, edematous, inflamed, indurated, or varicose.

Symptoms.—*Healing ulcer, healing sore*, or *union by second intention:* The floor is covered by pink or red firm granulations, and is moist, with slightly turbid, serous, non-irritating exudate. The edges are sloping and show a fine, bluish-white pellicle extending over the granulation tissue (*epithelization*). The ulcer is painless, the surrounding parts normal.

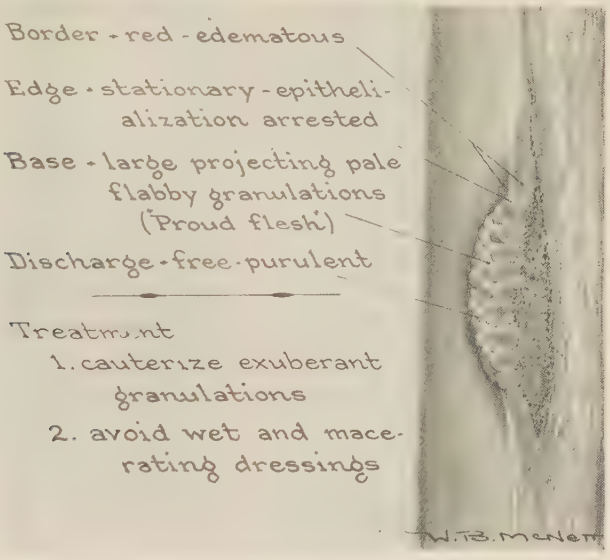

Border - red - edematous
Edge - stationary - epithelialization arrested
Base - large projecting pale flabby granulations ("Proud flesh")
Discharge - free - purulent
Treatment
1. cauterize exuberant granulations
2. avoid wet and macerating dressings

Fig. 9.—Weak edematous ulcer

Spreading ulcer usually shows a free purulent, acrid or offensive discharge, the edges and surrounding tissues are inflamed or necrotic, and there is absence of the thin peripheral layer of growing epithelium.

Phagedenic ulcer is one infected with virulent bacteria, and showing rapid destruction of tissue with spreading.

Weak ulcer is characterized by large edematous granulations (*proud flesh*) and delayed epithelization.

Varicose ulcers occur in the lower inner third of the leg, are surrounded by a diffuse brownish or bluish pigmentation, varicosities and dermatitis, or eczema. The edges are thin, the adjacent tissues show dilated varicose veins. The base or floor is shallow, with dark cyanotic granulations. The discharge is scanty.

Irritable ulcers have an unhealthy base, an irritating ichorous discharge, and are very sensitive.

Tuberculous ulcers result from the destructive infiltration of a surface by tubercles, or the rupture of a tuberculous abscess. The base is soft, pale, with feeble edematous granulations, the edges dull blue or purple, undermined, thinned out, and of irregular outline, with a thin watery or curdy discharge. The adjacent tissue may show tubercles (*crab-apple-jelly nodules*).

Bazin's Disease (*Erythema Induratum*).—A tuberculous ulceration with multiple, small, superficial lesions, occurring between the knee and the ankle, chiefly in tuberculous girls, often in connection with tuberculous cervical adenitis or phlyctenular conjunctivitis. Symptoms: Dusky, livid, indurated nodules which soften and ulcerate, forming small, shallow, multiple ulcers with ragged undermined edges. There is little pain except at the onset. The ulcer continues for weeks, months, or years, and heals after improvement of the general health.

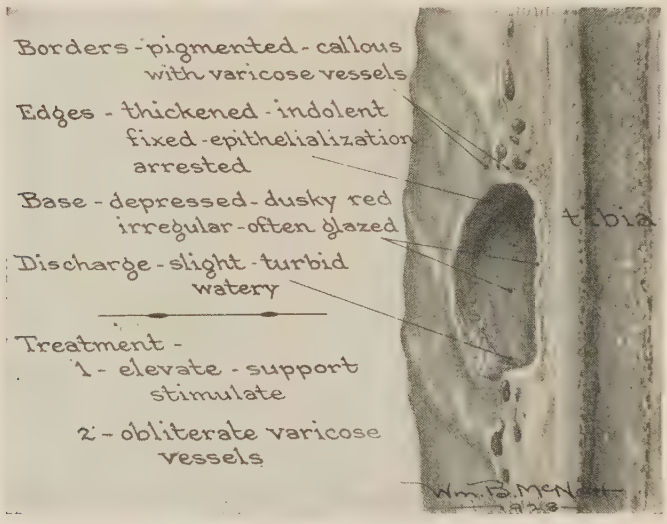


Fig. 10.—Varicose ulcer.

Syphilitic ulcer of the tertiary type results from the breaking down of a cutaneous or subcutaneous gumma. The ulcer is punched out, sinuous, serpiginous, or circinate in outline; the margins rounded, thin, soft, undermined, with a thin, glairy, offensive secretion and a wash-leather-like base of yellowish necrotic tissue. The adjacent tissues are congested, dark brown, or red. These ulcers are most frequent in the upper part of the leg around the knee-joint (in women), and over the ribs and sternum. After healing, a depressed, adherent, often pigmented cicatrix remains.

Trophic ulcer, bed-sore (*decubitus* or *pressure sore*) results from: (a) *Debilitating diseases*, such as typhoid, and other conditions requiring prolonged confinement in bed; (b) *anesthesia*, and *paralysis* especially from injuries or diseases of the spinal cord (cerebral palsies, poliomyelitis, neuritis); (c) *local conditions*, including *constant pressure*, as from casts, braces, splints, or bandages. The skin over bony prominences, as the sacrum, greater tuberosities of the femur, iliac crests, the condyles of the femur, the malleoli or other prominences about the ankles, is the usual seat of pressure sores. The affected skin becomes

dark red; vesicles or bullæ form and rupture; and rapid necrosis and ulceration to the bone often occur. The large joints may be opened, and death result from sepsis.

Perforating ulcer of the skin develops under the head of the metatarsal bone of the great toe and, less frequently, on the side and dorsum of the foot, toes, or hands, especially in peripheral neuritis, lesions of the brain or cord, general paralysis, locomotor ataxia, syringomyelia, diabetes, and arteriosclerosis. There is first a callosity followed by underlying suppuration, and a small hole forms which grows deeper and may involve the bone or joint (penetrating ulcer) and destroy tendons. The denuded surface usually is insensitive; the cavity is filled with offensive, decomposing epithelial cells and débris.

Scorbutic ulcer occurs in scurvy with prominent hemorrhagic granulations and the formation of spongy crusts.

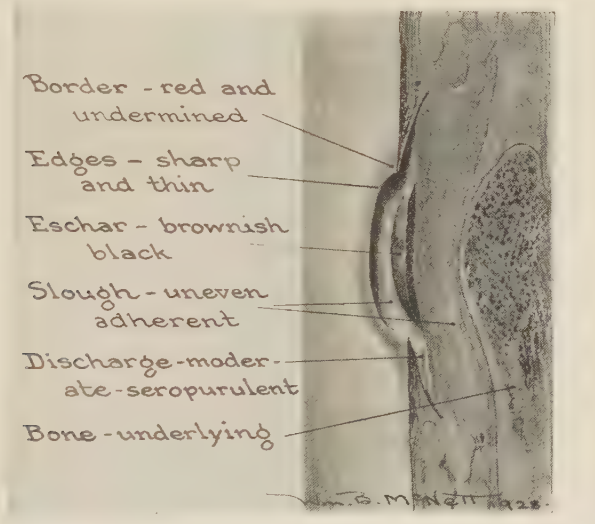

Border - red and undermined
Edges - sharp and thin
Eschar - brownish black
Slough - uneven adherent
Discharge - moderate - seropurulent
Bone - underlying

Fig. 11.—Pressure ulcer, decubitus or bed-sore.

Gouty Ulcer.—Tophi upon the toes and hands often ulcerate, leaving chronic ulcers, the base being infiltrated with the characteristic chalky sodium-urate deposit.

Site of the ulcer on skin or mucous membrane aids in the diagnosis. Syphilitic ulcers involve the dorsum of the tongue, the hard palate, the angle of the mouth, the upper third of the leg; varicose ulcers, the lower third of the leg; perforating ulcers, the sole of the foot; tuberculous ulcers, the face, the alæ of the nose; epitheliomatous ulcers, the lower lip, margins of the tongue, cheeks. Decubitus occurs over bony prominences.

Treatment of Ulcer.—General Principles.—The normal tendency of an ulcer is to heal. Healing is prevented by: (1) Infection, general and local. (2) Deficient circulation of blood or lymph. (3) Improper dressings, interfering with granulation and epithelization.

1. *Infection* is combated: By general measures, as in syphilis and tubercu-

losis; by local destruction or cauterization of infected tissue, as in phagedena; by special antiseptics, as iodin, copper sulphate, zinc chlorid, potassium permanganate, sodium hypochlorite; by exposure to ultraviolet light, Roentgen rays, or filtered rays from radium.

2. *Deficient circulation* may be from: (a) *Arterial occlusion* from pressure, disease, or spasm—requiring frequent cleansing and massage of the adjacent skin and frequent changes in position sympathectomy, intravascular injections, circulatory stimulants. (b) *Venous incompetency*, requiring support, elevation, occlusion, division, or excision of the veins with imperfect valves. (c) *Lymphatic insufficiency*, requiring elevation, massage, baking, hot baths, lymphangiorrhaphy, lymph drainage.

3. *Improper dressings*, such as dry occlusive dressings for infected wounds; failure to remove and neutralize irritating discharges; use of irritating, destructive antiseptics, as formalin, or those not suited to the particular infection; failure to protect the advancing epithelial edges by dressings that are epithelial conductors; and maceration of epithelial cells and granulations by too prolonged or excessive use of ointment or wet dressings.

Special Treatment.—*For Weak Ulcers:* The redundant granulations are removed by a 4 to 10 per cent. solution of silver nitrate or by copper sulphate, and the ulcer dressed with a 33 per cent. balsam of Peru in castor oil. A temporary dry dressing with thymol iodid, or exposure under an electric light is often valuable. Moist and wet dressings should be avoided until the condition of the ulcer improves.

For Callous Ulcers.—Elevation, massage, the application of a blister plaster, disinfection by cauterization, by applying a 10 per cent. chlorid of zinc solution or of phenol, followed by tincture of iodin and moist antiseptic dressings, are useful.

For Varicose Ulcers.—The ulcer is disinfected by carefully cleansing the surrounding area with alcohol or boric alcohol, and the ulcer painted with tincture of iodin. A useful dressing consists of a 50 per cent. red iodid-of-bismuth paste spread on lint, and extending only to the margins of the ulcer, covered with soft gauze wrung out of saturated boric solution. The dressing is held in place by an even supporting bandage of elastic cotton webbing or gauze applied from the toes to the knee. The leg should be kept elevated as much as possible. If the ulcer becomes clean, epithelization may be facilitated by covering only the denuded surface with oiled silk (Lister's green protective), gutta-percha tissue, or celluloid tissue (Impermeaphane or Cellosilk). This, in turn, is covered by a moist gauze dressing wrung out of boric alcohol and held by a snug supporting bandage.

Phagedenic ulcers are first to be disinfected. The actual cautery, the application of phenol, followed by tincture of iodin, a 10 per cent. solution of zinc chlorid, or the direct application of copper sulphate crystals may be used. A wet dressing of a 5 per cent. solution of permanganate of potash, or exposure of the ulcer under an incandescent electric light, will often be followed by healing.

Irritable ulcers should be anesthetized and asepticized by the application of pure liquefied phenol, followed by tincture of iodin, and then dressed with bismuth paste. This should promptly relieve the pain.

When an ulcer becomes small, very superficial and clean, healing may be completed under a crust or scab, formed by the use of dusting powders, as bismuth subiodid or thymol iodid. Infective and purulent secretions retained under a scab will, however, destroy the forming epithelial edges, interfere with normal granulation, and delay healing.

Tuberculous Ulcers.—Approved constitutional regimen; locally radiation by sun or ultraviolet light, Roentgen ray, or radium; passive hyperemia; stimulation by tincture of iodin or 2 per cent. solution of zinc chlorid, with the application of 50 per cent. red iodid-of-bismuth ointment. Occasionally rapid healing follows the injection of tuberculin in doses sufficient to cause a mild reaction.

Syphilitic Ulcers.—The treatment includes antisyphilitic treatment internally; arsphenamin, neo-arsphenamin intravenously; a 50 per cent. red iodid-of-bismuth ointment locally.

Perforating Ulcers.—The callous or epithelial overgrowth should be removed by a fine, sharp knife; the cavity disinfected with pure phenol, followed by tincture of iodin, or a brief application of a saturated solution of zinc chlorid *to cauterize and remove unhealthy granulations.* The cavity is then filled with bismuth paste. Persistence and recurrence are common.

Pressure ulcers (bed-sores) can be prevented in the paralyzed or helpless patient only by constant attention and careful nursing. There are required: (1) Frequent change of position, to prevent continuous pressure upon a bony prominence for more than two or three hours. (2) Stimulation of the skin by light massage, alcohol rubs; the use of pads, rings, or a water or air mattress to distribute pressure. (3) Great care and supervision in the padding of splints, plaster cases, and other appliances. (4) Protection of the skin from urine or other irritating discharges by frequent cleansing, exposure to the air, and dusting with zinc stearate.

The beginning ulcer is treated by a non-irritating, protecting powder, such as bismuth subnitrate 2 parts, thymol iodid 1 part, zinc stearate 1 part. With the development of the ulcer, active hyperemia produced by the ultraviolet rays is helpful. The ulcer is stimulated to heal by an occasional painting with tincture of iodin, or the application of balsam of Peru or tincture of myrrh. A useful ointment to stimulate granulations and facilitate the separation of slough consists of balsam of Peru 1 part, and the official compound resin cerate 10 parts.

Sinus.—A sinus is an inflammatory tract entering the tissues from a mucous or cutaneous surface with only one external opening, or an inflammatory tract open at one end. The inflammatory tube forming the sinus is lined by granulation tissue, or partially, by the ingrowth of epithelium from the surface. In chronic sinuses there is a dense outer layer of fibroconnective tissue.

Pathology.—A sinus usually is formed by the rupture of an abscess, and persists because of (1) the presence of a foreign substance at the base of the sinus, as necrosed bone or cartilage, an infected unabsorbable suture or ligature, or other organic or inorganic foreign body (a bullet, piece of metal, or fabric); (2) the persistence of a chronic infection, as tuberculosis, syphilis, actinomycosis; (3) the presence of animal parasites; (4) an epithelial lining, or cartilaginous

connective-tissue walls, or (5) the retention of secretions from tortuosity of the tract and insufficient drainage. A sinus may result from a congenital defect.

Diagnosis.—The sinus may be explored by probe, finger, or surgical incision. It is delineated, and certain foreign bodies shown, by roentgenograms taken before and after the injection of bismuth or barium paste, bromid solution, or iodized oil. The injection of colored solutions often demonstrates the presence of an unsuspected fistula.

Treatment of Acute and Subacute Sinuses.—Foreign bodies should be removed, the infected lining disinfected by swabbing with pure liquefied phenol followed by alcohol, or by a 50 per cent. solution of zinc chlorid. Drainage is facilitated by filling the tract with a 50 per cent. paste of bismuth subiodid in white petrolatum. Chronic sinuses not adjacent to large blood-vessels or

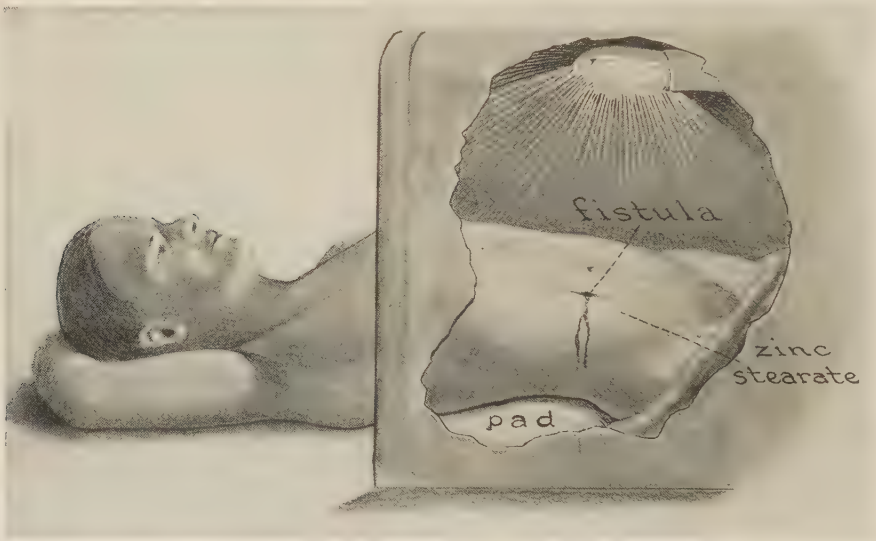


Fig. 12.—Open method of treating an abdominal fistula to prevent excoriation of the skin. The skin about the fistula is kept dry and thickly coated with zinc stearate, the secretions being caught upon a pad at the side under the patient. The patient's body is covered by a cradle and exposed to electric light.

important organs are best treated by disinfection (under the protection of a tourniquet) with a 10 per cent. solution of zinc chlorid, followed by delineation with a solution of methylene-blue, and the complete excision of the tract by sharp dissection and, finally, closure of the wound with or without drainage (Babcock).

Fistula is an inflammatory tract, open at both ends, connecting two surfaces covered by epithelium or, at times, endothelium. Usually a fistula is due to injury, a destructive inflammatory or neoplastic process, or a congenital defect.

Varieties.—*Congenital, acquired. Lacrimal*, connecting the lacrimal duct with the surface; *esophageal, tracheal, gastric, intestinal, colonic, vesical, renal, urethral, anal (fistula in ano).* An *internal fistula* connects internal hollow viscera, as

gastro-intestinal, *gastrocolic*, *enterovesical*, *enterovaginal*, *vesicovaginal*, *rectovaginal fistula*, and the like.

In time fistulæ are frequently lined by the ingrowth of epithelium.

Treatment.—Internal fistulæ usually require operative excision, and closure of the opening in each viscus. With an associated syphilitic, tuberculous, or malignant disease, the result of operative closure will rarely be successful, unless the causal process is also eradicated.

CHAPTER III

WOUNDS; INJURIES AND DISEASES RECEIVED FROM LOWER ANIMALS

A WOUND (*injury, trauma*) is a solution of continuity of the tissues of the body due to mechanical violence (traumatism). The term usually is restricted to open lesions of the soft tissues.

Closed wounds (*contusions, bruises*) are those without a surface opening or division of the skin.

Open wounds have an opening through the skin or mucous membrane and include: (1) *Incised*, having sharp, clean-cut edges. (2) *Lacerated* and *contused*, produced by a blunt instrument with tearing and bruising, including crushing, pulpifying wounds, and most traumatic amputations and avulsions. (3) *Punctured*, deep and narrow, due to small pointed instruments, and include stab wounds. (4) *Gunshot*, due to the action of firearms.

Penetrating wounds invade important cavities, such as the abdomen, thorax, arachnoid, or a joint, the cavity of the heart, larynx, or trachea.

Perforating wounds are those passing through a part, having a wound of entrance and one of exit, as of the head, neck, thorax, abdomen, or extremity.

Aseptic wound: one free from infection or active pathogenic micro-organism.

Septic wound: one infected by pathogenic organisms.

Poisoned wound: one in which venom or other poison has been introduced, including stings and snake bites.

Dissection wound: an infected wound acquired in dissection.

Simple wounds are those without serious associated injury. *Complicated wounds* are those associated with serious local injury, such as a fracture, dislocation, opening of a joint or large cavity of the body, rupture of a large artery, or division of an important nerve.

Brush burn is a superficial wound in which there is an association of mechanical violence and heat, as produced by contact with rapid movement.

Subcutaneous Wounds.—*Contusions* or *bruises* are due to blows, pressure, or crushing force without division of the skin. The injury varies in severity from the wheal produced by a whip, to the complete crushing, pulpification, or disorganization of a limb or other part.

Pathology.—Contusions are characterized by local swelling, which may be firm if the tissue is dense, as upon the scalp; or soft and boggy, if loose areolar tissue is involved. The swelling is due to extravasation into the tissues of blood from the ruptured blood-vessels, together with serum and cellular products. If the epidermis is separated from the corium by effused blood, hemorrhagic vesicles or bullæ (*blood-blisters*) form. More frequently petechia, ecchymosis, hemorrhagic extravasations, or hematoma are produced. If the blood enters

the skin, there is a characteristic "*black and blue*" appearance, gradually fading to yellow and green, and finally disappearing as the blood-pigments are removed by the leukocytes and the lymphatics.

The divided vessels are first sealed by blood-clot. The effused serum is absorbed by the lymphatics. If no infection occurs, the blood-clot gradually breaks down and is removed through the lymphatics and by the leukocytes.

Varieties.—1. *Wheal.*—A linear superficial contusion without hemorrhagic extravasation, often produced by the lash of a whip. The skin is raised and reddened from hyperemia and the effusion of serum and cells into the tissue, without the color evidence of a subcutaneous hemorrhage.

2. *Bruise.* A swelling rapidly follows the injury, with purplish discoloration from hemorrhage due to the rupture of subcutaneous blood-vessels. The color changes to brown, green, and yellow, as the blood-pigments causing the "black and blue" discoloration are gradually removed.

3. *Hemorrhagic Infiltration.—Suggillation* is characterized by the even distribution of blood through the bruised tissues.

4. *Hematoma, Blood Tumor.*—A well-circumscribed extravasation with a cavity containing liquid or clotted blood.

Symptoms.—The pain, dull, aching, throbbing, is due chiefly to tension. If in a sensitive area, or if the pressure is increased by resisting fascia, the pain is more intense than when less sensitive and more relaxed tissues are involved. In severe contusions there may be little pain, and a partial anesthesia of the tissues from the blow, or pressure of the exudate on the nerves. There is tenderness, swelling, and extravasation with discoloration of the tissues by blood. Delayed discolorations and effusions of the skin may occur from deep injuries, as the delayed superficial ecchymosis (*Battle's sign*) after fracture of the mastoid, and the discoloration and hemorrhagic bullæ that occur upon the skin a week or more after an underlying fracture of a long bone. If the hemorrhage into the tissues is marked, the tension and pressure may interrupt the circulation and, if not relieved, cause necrosis or gangrene.

Constitutional reaction from the absorption of nuclein ferment and nuclein is usually not marked. The constitutional anemia and shock vary with the location, the degree of the injury, and the amount of blood that has escaped from the vessels. Prolonged shock follows a large hemorrhage or the massive death of tissue.

Prognosis.—The part recovers: (1) Without evidence of injury; (2) with secondary fibrosis; (3) with the formation of a serous or hemorrhagic cyst; (4) after suppuration. The part dies from necrosis or gangrene.

Treatment.—(1) Sterilization of the overlying skin by the use of soap and water, followed by alcohol or other antiseptic. (2) Reduction of congestion and arrest of hemorrhage by rest, elevation, support, and, if the vitality of the part is not seriously impaired, the application of cold for the first twenty-four hours. After twenty-four hours the promotion of absorption and repair by heat, fomentations, with rest, elevation, and elastic pressure. After the third day, gentle but increasing massage and passive movements are used. For a large persistent hematoma aseptic aspiration of the blood, or incision and evacuation may be required. Any necessary repair of divided deep structures

should be delayed for ten days from the time of injury, so that the tissues may have time to recover from the early partial devitalization.

For *crushing, disorganizing injuries* of the extremities followed by strangling tension, a long incision should immediately be made through the skin and fascia to permit the escape of blood and exudate, the ligation of bleeding vessels, and relief from skin tension. The treatment is continued with large, moist, antiseptic fomentations, as 1 : 4000 bichlorid of mercury solution or a 2 per cent. solution of aluminum acetate. Such an incision, the wound being left open, will often prevent secondary necrosis, infection, or gangrene, and save a crushed arm or leg.

Strangulation of a part or tissue occurs from cording, the prolonged application of a cupping-glass, or the slipping of a tight ring over a part, usually the finger or penis, the venous obstruction and secondary swelling leading to strangulation.

The treatment is to remove the constriction, and treat the part by elevation, warm fomentations, and support. Incisions through the skin may be required to relieve tension, or amputation be necessary if gangrene has occurred.

Wounds Involving the Outer Layers of the Skin Only.—*Abrasion* or *excoriation* results from scratching, scraping, or friction. The outer layers of the skin are removed, and the sensitive mucous or papillary layer exposed. There is a moist red surface from which serum exudes, and stinging, burning pain.

Treatment.—The part should be cleansed by soap and water followed by one of the less irritating antiseptics, such as a 5 per cent. phenol, mercurophen 1 : 2000 or 1 : 2000 sublimate solution, ½ per cent. mercurochrome, or 2 per cent. aluminum acetate solution. A dusting-powder, such as bismuth subiodid or thymol iodid, is then thickly applied, and held in place by a sterile gauze pad and bandage. If dirt has been ground into the tissues, especially insoluble carbon (gunpowder grains), pustulation should be induced by painting with a 1 : 300 solution of bichlorid of mercury (von Bergmann). The pustules formed are opened after twenty-four to seventy-two hours, and the dirt removed by a moist aseptic sponge or a pledget of cotton.

Incised wounds usually are produced by sharp implements, as knives, razors, bits of glass. They have sharp, clean-cut edges with little bruising of the margins, and tend to gape widely and bleed freely.

Symptoms.—Free hemorrhage, wide gaping, sharp, stinging, burning pain, especially in the fingers. A wound that crosses the line of skin cleavage or tension plane gapes widely, while the lips of a wound following along the line of skin cleavage may be in contact. Wounds of the tips of the fingers, tongue, lip, external genitalia, and anal region are especially painful.

Prognosis depends upon the extent and location.

Incised wounds, the edges of which are held in contact without movement, heal by *first intention* or by *adhesion*, or, if the lips of the wound are separated or if infection occurs, by *secondary intention* or *granulation*. Incised wounds may be associated with severe shock, hemorrhage, or be followed by septic infection.

Treatment consists of: (1) *Arrest of hemorrhage* by pressure, forcipressure,

and ligation. (2) *Reaction from shock.* (3) *Sterilization of the wound field.* Compresses, wet with 3½ per cent. tincture of iodin solution, are placed in the wound while the surrounding skin is thoroughly painted with 3½ per cent. tincture of iodin; or the wound may be packed with compresses wet with 5 per cent. phenol or 1 : 2000 bichlorid of mercury solution, while the surrounding skin is cleansed by scrubbing with tincture of green soap and water, followed by alcohol and finally bichlorid solution. (4) *Wound approximation* with accurate union of superficial and deep divided structures without tension. Drainage is only used (a) where oozing or bleeding cannot completely be controlled, (b) where the wound communicates with a deep cavity and there is a possibility of extravasation, and (c) where severe infection is feared.

The *after-treatment* includes (1) support and protection for the wound; (2) rest of the affected part or, if the wound is extensive, the entire body; (3) the

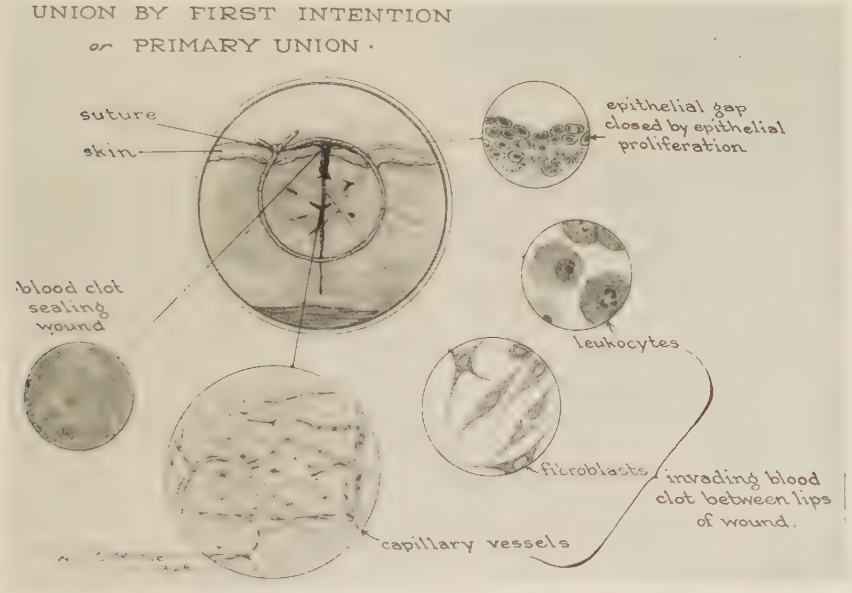


Fig. 13.—Pathologic changes in union by first intention.

treatment of any associated blood dyscrasia. Primary union is often prevented because the patient does not remain in bed or keep the injured part at rest.

Wound Healing.—(1) *First Intention:* The tissues being accurately approximated, union occurs without gap, loss of tissue, or the formation of granulations, and results in the formation of a linear scar. (2) *Second Intention* or *Healing by Granulation:* A gap exists which is first filled by granulations. These organize and contract with the formation of connective tissue. The surface is covered by epithelium (*epithelization*) usually forming a wide and disfiguring scar. (3) *Third Intention:* The surfaces of a granulating wound having been brought together, healing occurs by union of the apposed granulating surfaces. (4) *Healing Under a Scab:* The surface defect is covered by a mass of adherent dried blood or wound exudation, under which repair takes place. (5) *Healing by Organization of Blood-clot:* The clot is invaded by formative cells, removed

by the leukocytes, and replaced by granulation tissue. The blood-clot serves as a scaffolding for forming connective tissue.

Lacerated and Contused Wounds.—Etiology.—(1) *Blows* or *falls* against blunt or irregular objects, such as contact with pavement, stones, clubs, hammers, and the like. (2) *Machinery*, the part being caught in revolving cog-wheels, between rollers, or by moving elevators. (3) *Railway and Motor Injury:* Laceration and crushing between bumpers or under car wheels. (4) *From the teeth, horns, or claws of animals.* (5) *Gunshot injuries* usually are characterized by marked laceration and contusion. (6) *Brush burns* show the association of abrasion with the heat produced by friction from rapid movement. They result from contact with moving belts or wheels, or even from sliding on ice or snow.

Avulsion.—A part of the body is torn away. The scalp may be avulsed from the long hair of a woman being caught in a revolving belt; or the hand, fingers, toes, or limb detached by moving machinery. The skin is torn away at a higher level, and its edges constrict the muscles which protrude with the elastic larger blood-vessels. The bone may protrude, the tendons may be torn from their muscular attachments and from the sheath. The larger nerve trunks are often the last structures to give way.

Symptoms of Lacerated and Contused Wounds.—The surface of the wound is ecchymotic and contused; the lips of the wound are bruised, torn, and irregular. Gaping and hemorrhage are slight; the pain is dull, aching, or throbbing. Compound or comminuted fractures may be associated. Foreign bodies and dirt are often ground or embedded in the tissue. The wound usually becomes red and inflamed; the edges dark, necrotic, and sloughing. Suppuration is common, and healing often occurs by granulation.

Constitutional symptoms are especially marked with primary, relatively intense shock which is increased by the absorption of histamin or other wound products (Cannon). There is (1) *primary shock* and *depression*, followed by (2) *reaction, infection*, and *inflammation*, succeeded by a period of (3) *sloughing, suppuration*, and *exhaustion*, and finally (4) *granulation* and *healing.*

Dangers.—*Sloughing* is influenced by: (1) The *severity* of the trauma; (2) the *vascularity* and *vitality* of the tissue. A force that devitalizes the tissues of the hands, feet or extremities, and is there followed by extensive sloughing, may cause no gross necrosis upon the scalp or face. The vulnerability of tissues to contusion and laceration progressively increases from the scalp, face, neck, trunk, lower arm, leg, and hand to the foot. (3) *Infection:* Devitalized tissues are especially susceptible to infection, necrosis, and gas gangrene. It is to be recalled that offensive, decomposing material, and even night soil in wounds may be free from pathogenic bacteria and cause no infection. (4) *Age* and *dyscrasia* of the patient. Senility, obesity, arteriosclerosis, syphilis, or other disease may delay the healing of the wound. (5) *Treatment used*, including: (a) *Constriction* occurring during the secondary swelling, from the unwise introduction of sutures or from failure to divide the restraining overlying skin. (b) *Insufficient drainage.* (c) *Traumatizing manipulation.* (d) *Strong antiseptics.* (e) *Failure* to maintain the normal temperature of the part. (f) *Lack of local and general rest.* (g) *Presence of foreign bodies.*

Wounds from contact with garden or other soil may contain the spores of tetanus. Wounds contaminated by shotgun wads, woolen clothing, or fecal material are subject to gas gangrene.

Treatment.—(1) *Reaction from shock and arrest of hemorrhage.* Amputation, anesthetization, or extensive wound manipulation during the period of intense shock are frequently fatal and should be avoided. Hemorrhage should be arrested, if possible, in the wound by forcipressure, packing, or, if the patient's condition is very serious, by the temporary guarded application of a tourniquet, and a moist antiseptic dressing and an immobilizing support applied. As soon as the patient is out of intense shock, the wound should be sterilized and asepticized, preferably under nitrous-oxid or ethylene-oxygen anesthesia. The surrounding skin is cleansed by turpentine or ether, followed by alcohol and tincture of iodin. Ether, followed by half-strength tincture of iodin, is poured over the wounded surface and foreign bodies removed, and tissue devitalized or infiltrated with dirt is excised by sharp dissection. (2) *Débridement*, or the excision of the contused wound surfaces, is practised if it does not seriously increase the disability and deformity or prevent wound approximation. Serous cavities should immediately be closed. (3) Prophylatic injection of antitetanic serum.

Wound Closure.—Suture of Wounds: 1. *Primary or immediate closure*, after careful mechanical and chemical sterilization, is indicated for all wounds of the scalp and face, and for most wounds of the trunk.

2. *Delayed Primary Closure:* The wound is filled with gauze wet with a weak antiseptic solution such as 1 : 4000 sublimate solution, 2 per cent. of tincture of iodin in water, or the Carrel-Dakin treatment employed, for the first twenty-four to seventy-two hours. Delayed primary closure is used (a) where the patient is in serious shock; (b) where delay is desirable to determine the viability of the tissues, and to avoid primary tension or constriction; (c) where there is continued oozing that can best be controlled by packing; (d) to determine the degree of wound infection.

Delayed primary suture is especially adapted to fresh lacerated and contused wounds and open fractures. Bacteriologic tests are made at the first dressing, twelve to twenty-four hours after the primary excision of devitalized tissue, and at the second dressing after thirty-six to forty-eight hours. If smears made at the time of the first dressing do not show the presence of streptococci, or more than one micro-organism to a field, the wound is sutured. Freshening of the wound edges is unnecessary. If smears made at the second dressing show an increasing number of bacteria, the secondary suture is omitted. In this way secondary septic complications may be avoided.

3. *Secondary closure*, or closure after sloughing has ceased and granulation started, is advisable where: (a) The vitality of the tissues is greatly impaired; (b) gas gangrene or other serious infection, best handled with an open wound, is feared; (c) where the constitutional condition through diabetes, arteriosclerosis, active syphilis, or other cause interferes with normal healing.

Secondary suture is therefore reserved for lacerated, contused, and badly contaminated wounds that, from the devitalization of tissue or from threatening infection, are not in condition for suture during the first six days. While

it gives the greatest security against secondary infection and necrosis, healing is retarded and the anatomic restitution is not as perfect as with primary suture. The secondary suture is made when the microbic curve shown by smears of wound secretion is below one bacterium to four fields on two successive examinations, and the cultures show no streptococci. The wound edges should be freshened.

Articular wounds should be treated by immediate suture unless the associated bone-lesions are extensive. Nearly all wounds of the head and face, and non-contused wounds of the feet and hands, are treated by immediate suture. With contused wounds and compound fractures of the extremities, suture should be made within twelve hours only when the patient can be continuously watched, as a rapid gangrenous or phlegmonous inflammation may follow.

Support of the wound is obtained by even elastic compression, by the application of layers of sterile gauze over the wound, followed by cotton and a wide, evenly applied supporting bandage. To insure rest and avoid tension upon the wound it is often desirable to bandage the part to a support or splint and, with all extensive wounds, the patient should be kept at rest in bed. If the patient is a syphilitic, diabetic, nephritic, or has other serious constitutional disease, this condition should receive appropriate attention. Drainage is only used when required by extravasation of blood, serum, or pus.

Healing is prevented or delayed by: (1) Imperfect hemostasis. (2) Foreign bodies. (3) Sepsis. (4) Imperfect apposition, as from the stitches being improperly inserted, too tense, too easily absorbed, or too quickly removed. (5) Wound tension. (6) Insufficient drainage. (7) Lack of rest. (8) Constitutional disease, such as tuberculosis, syphilis, or arteriosclerosis.

Crushing Injury.—As already mentioned in severe crushes, especially of the extremities, tension and interference with circulation from secondary swelling should be prevented by one or more free longitudinal incisions through the skin, if the skin is not already sufficiently divided. Gentle primary suture of divided tendons, muscles, nerves, and larger blood-vessels may be undertaken with relative safety, provided tension from the overlying skin and aponeurosis is prevented. An arm or hand, crushed between the bumpers of a train or apparently pulpified by passing between cog-wheels, properly treated by asepticization, free division of the overlying skin, complete rest, avoidance of all sutures, and the constant application of warm, wet, mildly antiseptic dressings, will occasionally recover in a most surprising way.

Amputations.—With avulsion or removal of a part, amputation to produce a better stump usually is necessary. With the hand or foot, however, if a part has been removed and the bones left protruding, function often may be better conserved by grafting a pedicled flap to cover the stump. In this way a stump against which the thumb may be apposed, a considerable length of finger or thumb, or sufficient of the anterior part of the foot to render unnecessary the wearing of a prosthesis may be conserved.

Site.—(1) Amputations are more frequently demanded for injuries of the lower extremity than the upper. (2) Primary amputations for injury of the fingers or hand are rarely required. By delay and appropriate treatment the amputation may be found unnecessary, or the precise extent of devitalization

determined. (3) In the elderly, asthenic, diabetic, arteriosclerotic—severe crushing injuries, particularly of the lower extremities, are often better treated by primary amputation. These patients withstand poorly chronic sloughing and infection. (4) The development of gangrene necessitates early operation. A limb that is so seriously disorganized as to be functionally useless should be amputated.

Secondary infection and suppuration should be treated by: (1) Free opening of the wound for the escape of inflammatory products, and to relieve tension and constriction. (With streptococcic edema incisions are rarely necessary.) (2) Complete rest, general and local. (3) Moist fomentations or irrigations. (4) Support, without constriction.

Fig. 14.—Traumatic amputation of the fingers with splintering of phalanges from catching the hand in corn shredder.

Punctured and stab wounds vary from the prick of a needle to the extensive penetrating or perforating wounds made by a bayonet, sword, spear, or arrow. The wounds are long, narrow, may traverse important blood-vessels, nerves or other structures, drain poorly, and are very serious if infected. The following points should be considered:

Fig. 15.—A powerful serviceable hand ten years after covering splintered bones and lacerated soft tissues with double pedicled flap from abdomen.

Fig. 16.—Strong useful hand with flexible stump produced by covering lacerated comminuted bones and soft tissues with a double pedicled flap from the anterior abdominal wall. The stump shows excellent flexion and extension.

1. The cleanness or contamination of the nail, knife, spear, or other object responsible for the wound. Anilin from anilin pencils in punctured wounds causes local necrosis and aseptic fistula formation.

2. The possibility of retained foreign bodies, as a splinter of wood or bit of clothing.

3. Injury of deeper structures, penetration into serous cavities, as joints, the peritoneal or pleural cavity or viscera, the division of nerves, blood-vessels, or other important structures.

Treatment.—(1) *Arrest of Hemorrhage:* The bleeding should be controlled by compression of a pad or bandage or, if an important artery has been traversed, it may be necessary to expose and ligate the bleeding vessel. (2) Any retained *foreign body* should be removed. Particles of anilin should be excised with the adjacent colored tissue. (3) *Antisepsis:* (a) If the wound is evidently not penetrating, and due to an apparently clean object, the area of the wound is painted with tincture of iodin, an occlusive dressing applied, and the part put at rest. Probing and other meddlesome manipulations are to be avoided. (b) If the puncture has been made by a rusty nail or a presumably contaminated object, the wound should be swabbed to the depths by pure carbolic acid, followed by tincture of iodin on an applicator. A wet antiseptic dressing or the yellow oxid-of-mercury ointment is then applied over the wound, antitetanic serum given, and the patient put at complete rest.

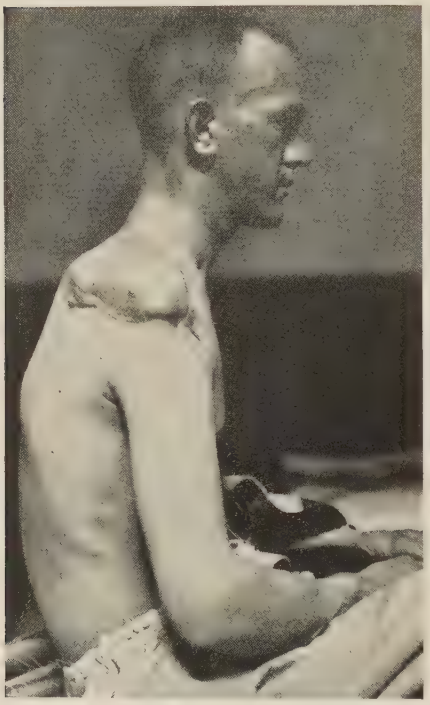


Fig. 17.—Healed gunshot wound of the shoulder.

Penetrating wounds entering the abdomen, thorax, or cranium should be laid open and explored. Foreign bodies, of organic origin, such as splinters of wood, thorns, cactus spines, fish bones, bits of glass, arrows, should be removed. Needles, bullets, metal particles, and other objects opaque to the Roentgen ray should be carefully localized immediately before the operation to avoid displacement or migration. If deeply and safely placed such foreign metallic objects, which are causing no symptoms, may be left undisturbed. The finding of a deeply embedded fragment of needle, as in the hand, is often very difficult and efforts at extraction often do more harm than the retained body. Barbed instruments, such as fish-hooks or crochet needles, are, at times, best removed by pushing the barbed point on through the skin, removing it by a cutting pliers, and then withdrawing. If infection or suppuration occurs, free incision, removal of the foreign body, and drainage is indicated.

Gunshot wounds vary in the effects produced, according to the velocity and size of the missile and the area wounded, from a simple drilling or perforating wound to extensive disorganization or explosive disruption of tissue.

Treatment.—(1) *Small penetrating* or perforating wounds without complication are treated by disinfecting the skin surface with iodin, and using occlusion, rest, and support. (2) *Large lacerated*, contused, and complicated wounds by: (a) Débridement, and primary or delayed primary closure; (b) hypertonic salt packs or a 10 per cent. salt solution (Wright); (c) Carrel-Dakin treatment with hypochlorite solution; (d) cleansing with alcohol and the application of B. I. P. P. (bismuth iodoform paraffin paste—Rutherford Morrison); or (e) flavine packs. Tetanus antitoxin is used in all cases.

Primary closure is usually applicable in the first twelve hours; *delayed primary closure*, twelve to twenty-four hours after the injury, provided a smear made from the wound secretions shows an absence of streptococci, and not more than one organism to a microscopic field. After twenty-four hours, especially if there is evidence of beginning infection, only *secondary closure* can be considered.

Bullet wounds with a small orifice and without internal complication are treated, without prolonged or undue manipulation, by asepticizing the adjacent skin with iodin or other antiseptic, and applying an occlusive dressing. If there has been an extensive laceration and devitalization of tissues, or the division of an important artery with the formation of large arterial hematoma, an incision, with arrest of hemorrhage, removal of devitalized tissue, and drainage are employed. Divided important nerves are immediately sutured and, if possible, sequestered between living muscles. Compound fractures from bullets usually require wound excision.

Artillery Projectiles.—High-explosive shell wounds are characterized by extensive laceration and by foreign bodies in the tissues. All bits of fabric or other organic substance and the larger metal fragments should be removed. Minute metallic particles may be left.

Incision.—Through-and-through wounds with a retained projectile may require incision to relieve pressure, evacuate secretions, remove foreign bodies, and to excise contaminated and devitalized tissue. Complete excision of the wound *en masse* is rarely feasible or desirable. The situation and direction of the wound having been determined, a longitudinal incision (if in a limb), or an incision along the line of skin cleavage (if of the trunk or neck), is made with excision of the wound margins. The deeper wound is explored with the least possible anatomical damage. A transverse incision should, as a rule, not be used upon the arm or leg. Both anterior and posterior incisions may be required.

After Incision.—The parts are united by primary or delayed suture. After a delayed excision, secondary closure is preferred. Injured muscle should be resected to living healthy muscle, as shown by redness, vascularity, and contractility. In open fractures detached free portions of bone not in a clean field should be removed. Attached bone fragments are not removed. The fragments may be safely retained in case open wound treatment is employed, provided the fragments do not interfere with free drainage.

Wounds of joints are treated by: (1) *Complete closure*, or (2) *closure* of the capsule *with drainage* of the superficial tissues. Drains should not be introduced into joints as a primary procedure.

Immediate operation is indicated except in certain bullet wounds having a small orifice occurring without fracture. The routine treatment consists of: (1) Roentgen study. (2) Wide aseptic arthrotomy with the excision of the wound tract, exploration of the joint; removal of foreign bodies, such as bone, splinters, and blood-clots. (3) Complete closure of the wound, or closure of capsule with superficial drainage, supportive dressings with elastic pressure and immobilization. A resection, either typical or atypical, should only be used where there is marked comminution of bone. With the knee the operation should be primary; with the elbow and shoulder, secondary, after other measures have failed. If severe suppurative arthritis develops, a wide arthrotomy with complete immobilization and progressive disinfection of the wound, or Willem's treatment by active mobilization should be used. If this fails, resection of the joint followed by free drainage, and separation of the bony surfaces by extension should be used. In grave cases, with disorganization of the joint, especially in the elderly or debilitated, an immediate resection or amputation should be done.

Wounds of Blood-vessels.—Blood-vessels may be contused or lacerated. Contusions, if severe, are followed by thrombosis, secondary embolism, or necrosis and hemorrhage. Arterial thrombosis should be treated by ligation above and below the clot; arteriotomy and evacuation of clot should not be performed.

Hemorrhage.—1. *External hemorrhage* is controlled, if moderate, by compression made above or over the wound; if severe, by tourniquet temporarily or, better, by direct ligature or forcipressure. The bleeding point is exposed and a ligature placed above and below on an undamaged section of the vessel. A vascular suture is rarely feasible from the devitalization of the artery. *Secondary arterial hemorrhage* should be treated by ligature at both ends of the injured vessel or, if this is impossible, by forcipressure, the proximal ligation of a main artery, or amputation.

2. A large, diffused, arterial hematoma should be treated, after provisional hemostasis, (a) by a tourniquet, or exposure and temporary occlusion of the main artery; (b) by opening and evacuating the hematoma, suturing the wound in the vessel, or (c) by ligatures applied immediately above and below the arterial wound. If the axillary, common carotid, common femoral, or popliteal arteries are involved, where occlusion may be followed by gangrene or cerebral degeneration from deficient collateral circulation, the ends of the wounded vessel may be connected temporarily by Tuffier's silver tube coated with paraffin. After four or five days the tube is removed, and the artery ligated above and below the point of injury. The use of the tube gives time for a progressive development of the collateral circulation.

Diffused hematoma may be associated with gangrene. The simultaneous ligation of both the main artery and vein of a limb is less often followed by gangrene than the ligation of the artery alone (Makins).

Traumatic Aneurysm.—Under provisional hemostasis (1) the opening in the artery is exposed and sutured; (2) the aneurysm is excised, with end-to-end suture of the resected artery; (3) the sac is evacuated, resected or excised, with proximal and distal ligation of the artery, or (4) with old traumatic aneurysms

having a well-developed sac, an aneurysmorrhaphy of the Matas type may be feasible.

Arteriovenous aneurysms are more frequent and less dangerous than the arterial, and less often accompanied by gangrene. The treatment is: (1) Extirpation of the sac with suture of the opening in the artery and vein. (2) Extirpation with end-to-end suture of the artery and vein, or (3) ligation, proximal and distal, of both the artery and vein. Proximal ligation of the artery alone is dangerous to the integrity of the limb. The arterial blood is thus shunted back through the false opening into the vein, depriving the limb of its normal arterial circulation. The limb "bleeds to death" through the vein.

Varieties of Wound Treatment.—1. **Exposure to the Air:** When a surgically clean, carefully united wound is exposed to the air, the wound secretions dry between the edges of the wound, forming a scab which, as long as moisture is absent, forms a barrier to the ingrowth of bacteria and favors primary healing. Such exposure has been used by various operators even in the treatment of abdominal wounds with good results.

2. **Dry Dressing.**—As a rule, support and protection of the united wound is desirable to prevent handling or displacement of the adherent wound edges. A pad of sterile gauze is therefore applied over the wound; the pad is held in place and the wound supported by straps and a bandage. The dressings should be permeable to the air, to permit evaporation of perspiration and to prevent maceration and bacterial growth.

3. **Powder Dressing.**—To maintain dryness of the wound, or to modify the healing process, an open or closed wound may be dusted with a surgical powder, such as: (a) *Indifferent aseptic powders* to absorb secretions, promote dryness, and facilitate the formation of a dry scab. The powders used include: talcum or powdered soap-stone, zinc oxid, animal charcoal, powdered sugar, lycopodium, burnt alum. The charcoal is valuable in absorbing wound odors. Lycopodium should rarely be used, as the spores may cause pruritus, especially about mucocutaneous margins (*e. g.*, the anus). Antiseptics or other medicaments may be added to the powder, such as chloral, silver nitrate, balsam of Peru, phenol, or iodoform.

(b) *Protective powders* are impermeable to watery solutions, and prevent maceration and ulceration of the skin from irritating wound discharges or the erosive fluids escaping from fistulæ of the alimentary tract and, as a rule, will be found more effective than protection by ointment or paste. Stearate of zinc is the best protective and should be dredged in a thick layer upon the dry skin. The preparation should be tested by pouring water upon cloth which has been coated with the powder. With a good preparation the water will not enter the fabric.

(c) *Anesthetic powders* are used to relieve pain in wounds and include: Anesthesin, novocain, 1 per cent.; orthoform; acetanilid, 5 to 50 per cent.; chlorbutanol (chloretone), 5 to 50 per cent. strength; phenol, 1 to 5 per cent. Anesthesin and orthoform retard wound healing; acetanilid on absorption causes circulatory depression and destructive changes in the blood; chlorbutanol, stupor and coma. The use of anesthetic powders in wounds should, therefore, be limited.

As a rule, hypersensitiveness in a wound is due to bacterial infection and may be overcome by the disinfection of the wound surface with a 4 to 10 per cent. solution of nitrate of silver, by liquefied phenol followed by alcohol or, if the wound is extensive, by continued exposure of the wound to light and air.

(d) *Antiseptic Powders.*—The antiseptic action of the powder in the wound is often very limited. *Iodoform* (von Mosetig-Moorhof, 1880) may contain living, although rarely pathogenic bacteria. The unpleasant odor of iodoform may be covered by mixture with ground tonka-beans, ground coffee, Peruvian balsam, or turpentine. Toxic symptoms often follow the free use of iodoform in wounds. Other iodin-containing powders are vioform (iodochloroxyquinolin), isoform (para-iodo-anisol), sodium sozoiodolicum (diiodoparaphenol sulphate), aristol (dithymoliodid). Bismuth powders, as a rule, are

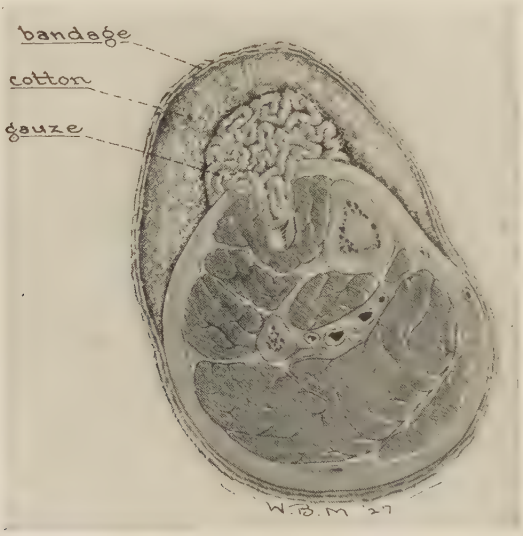


Fig. 18.—Principle of the moist dressing: The wound is covered by moist gauze over which there is placed a thick layer of absorbent cotton held in place by a bandage. By evaporation the moist dressing soon becomes dry, interfering with capillary drainage. Only wet dressings should be used where there is active infection or where very free drainage is desired.

rather sedative, non-irritating, and favor wound healing. From the subnitrate of bismuth, particularly, absorption of sufficient bismuth to cause a blue line on the gums, skin eruptions, and other evidence of bismuth poisoning has repeatedly occurred. The bismuth powders chiefly used are bismuth subgallate (dermatol), bismuth subiodid (a deep red powder), bismuth subnitrate, bismuth carbonate, airoform (bismuth oxyiodogallate), xeroform (tribromphenol bismuth), noviform, and anusol (bismuth iodoresorcinsulphonate).

These powders may be mixed or diluted with indifferent powders, just as indifferent powders may be given antiseptic qualities by admixture with various antiseptics, such as: phenol, $\frac{1}{2}$ to 5 per cent.; phenol-camphor; silver salts, $\frac{1}{2}$ to 3 per cent. of silver nitrate; organic silver compounds, such as protargol, argyrol, colloidal silver, collargol (Credé, 1895); or antiseptic dye preparations

such as flavine or acriflavine, methylene-blue, methyl-violet, pyoktanin, methyl-green.

(e) *Bacteriophage powders*—made from bacteria or their cultures, especially the pneumococcus, staphylococcus, streptococcus—show more or less specific antiseptic properties when dusted into a wound.

Upon granulating wounds that are not aseptic, or not very superficial, the dusting-powder combines with the wound secretion and adheres to the adjacent skin, forming a more or less impermeable scab, under which the secretions decompose, the granulations become unhealthy, and the ingrowth of epithelium is interrupted. When the adherent scab is detached, the ingrowing epithelial margin is torn. Dusting-powders, therefore, even though antiseptic, may interfere with drainage, favor wound infection, and delay healing except in small and very superficial wounds.

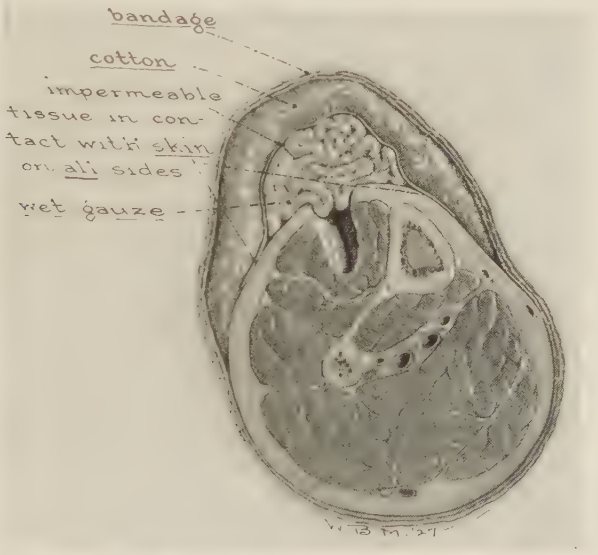


Fig. 19.—Principle of the wet dressing or antiseptic poultice: Wet gauze dressing placed in and over the wound is covered by impermeable tissue reaching the skin upon all sides. The tissue is surrounded by a thick insulating protecting layer of cotton held in place by an external bandage.

4. **Moist dressings** facilitate drainage, but, unless frequently moistened, evaporate and become dry, and have the disadvantages of adherent dry dressings.

5. **Wet dressings** are not only applied wet, but the wetness is maintained by a continuous or intermittent introduction of liquid, or by an impermeable covering. Wet dressings are preferred for all infected wounds. (a) *Antiseptic poultice* is a very satisfactory form of wet dressing, requiring but little attention. The wound is cleansed and covered by a large mass of crumpled gauze, wringing wet with the desired solution; over this an impermeable layer of gutta-percha tissue, mackintosh, oil silk, rubber-dam, cellosilk, or similar substance is placed, sufficiently large to reach the skin upon all sides of the wound. A thick covering layer of absorbent cotton, extending well beyond the imperme-

able layer, is used to retain heat, absorb the escaping secretions and give support, and is retained by a carefully applied bandage. Such a dressing remains wet for days, facilitating drainage and maintaining moisture, heat, and support about the wound area. Hydraulic methods of moistening the wound dressings require more attention, and frequently are less satisfactory in general surgical practice. A large absorbent dressing is applied, held in place by a bandage, to which the liquid is added every one to three hours by pouring it upon or through the dressings, or the liquid is injected through rubber tubes incorporated in the dressing.

Solutions Used for Wet and Moist Dressings.—1. *Physiologic solutions*, including saline solution (physiologic salt solution), a sterile 0.9 per cent. solution of sodium chlorid in water, and *Ringer's solution* are relatively free from irritating properties and do not hemolyze red blood-cells.

2. *Hypertonic salt solution*, 3 per cent., added to saturated aqueous solutions of sodium chlorid are used to stimulate osmosis and wound drainage (Wright). To aid in the process salt packs, small bags or tablets of salt, may be placed within the wound.

3. *Sedative Solutions.—Liquor alumini acetatis* (Burow's solution) officially contains 8 per cent. of aluminum acetate, and is used in from 1 to 4 per cent. strength; lead-water (a 1 to 5 per cent. mixture of liquor plumbi subacetatis in sterile water) is antipruritic, sedative, slightly astringent, and non-irritating. Boric acid solution, 2 to 3 per cent. (a saturated solution is about 3 per cent.), is a non-irritating, mild antiseptic to be used safely on irritated or eczematous surfaces and delicate mucous membranes. It is valuable in pyocyaneus infection.

4. *Antiseptic Lotions.*—(a) *Mercuric chlorid* (*bichlorid solution, sublimate solution*) is used as a wet or moist dressing in strengths of from 1 : 2000 to 1 : 10,000, with an average strength of 1 : 4000. The stronger solutions applied over large surfaces, or for prolonged periods of time, may cause mercurial poisoning through absorption. Bichlorid solutions, while locally somewhat irritating, are easily decomposed by organic matter, do not interfere with the formation of granulation tissue, and, unless strong, have only a limited effect upon epithelization. The healing process is not arrested as by solutions of formalin, phenol, or even to the same degree as by mercurochrome or lysol. Sublimate may be combined with sodium chlorid, ammonium chlorid or citric acid (Laplace), and is decomposed by alkalies and other metallic salts. It attacks metal utensils and instruments.

(b) *Biniodid of mercury* or the *oxycyanid of mercury* may be used in the same strengths and for the same purposes as the bichlorid, the solutions being less irritating, more stable, and having little corrosive action upon most metals or metallic instruments.

(c) *Phenol* and *cresol* solutions, including solutions of carbolic acid, liquor cresolis compound (lysol), tricresol, should not be used for wet or moist dressings, as they may retard wound healing. Solutions of phenol produce local necrosis and even gangrene.

(d) *Iodin solution* ($\frac{1}{2}$ to 2 per cent.) or *bromin solution* (1 : 3000 to 1 : 10,000) may be used as a stimulant, antiseptic wet dressing.

(e) *Permanganate of potash*, from 1 per cent. to a saturated solution, is

antiseptic and deodorant, valuable as a wet dressing in sloughing, offensive wounds. The solution is not stable, easily oxidized, easily decomposed, and has the objectionable feature of staining dressings and the skin a dark brown color. The stain may be removed by a solution of oxalic acid.

(f) *Dilute Alcoholic Solution.*—Ten to 70 per cent. ethyl alcohol may be combined with boric acid solution to form a stimulating antiseptic. In concentration it interferes with wound healing.

Drainage of Wounds.—Wound secretions are increased by the imperfect arrest of bleeding (imperfect hemostasis), by the use of irritating antiseptics, by traumatism, by removal of lymphatics or the blocking of the lymph drainage (present in certain infections, as in elephantiasis and in carcinoma), by venous congestion, and general anasarca.

Drains are used to permit the escape of wound secretions during the first twelve to forty-eight hours. If left over forty-eight hours drains frequently act as irritants, and favor the formation of pus in the wound through the ingrowth of bacteria from the skin along the drain, and from the local pressure and tissue irritation produced in the depths of the wound by the foreign body.

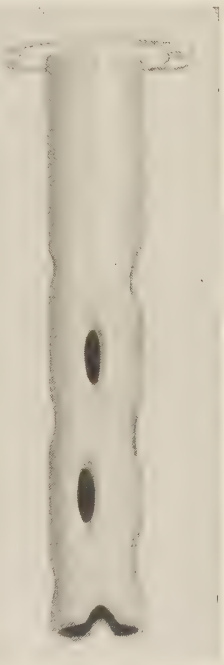


Fig. 20.—Drain of soft-rubber tubing with openings and guarding safety-pins.

Tube drains are usually made of soft rubber, but are also made of hard rubber, glass, silver, or other metal. With through-and-through drains both ends of the drain project from the body through separate openings or different parts of the same wound. If the end of the drain is left in the wound it is usually cut like a fish-tail, to reduce the obstruction of drainage by the pressure of tissues. Lateral openings are made in the tube where it is desired to facilitate the drainage. The tube should produce a minimum of pressure, and the lateral openings should not be so large that adjacent tissues (as portions of intestines) may enter the opening and perhaps be strangulated. To prevent injurious pressure effects upon the tissues the tube should be rotated or loosened daily, unless it has been firmly fastened in some viscus, as the urinary or gall-bladder. To facilitate tubular drainage, especially where the escape of wound secretions will be aided by capillary attraction, the tube may be split laterally or spirally and enclose a loose gauze drain. This is especially desirable when the end of the gauze is used as a tampon to make pressure or for the arrest of hemorrhage.

Metal tubes used for drains may be perforated, made of a coil of wire or a spiral strip of tubing, to facilitate drainage along the length of the tube. Prolonged pressure of a drain in the wound may cause local necrosis and the perforation of a viscus or blood-vessel. The drain should be made of good material, and on removal it should be inspected to see that no piece has been pulled off and retained in the wound.

Capillary drainage may be obtained by strands of silver wire, horse-hair, silkworm-gut, or catgut. The strands are usually introduced between the stitches used to close the wound.

Gauze Drainage.—Gauze drains supply capillary drainage, and are also useful in packing the wound for the arrest of hemorrhage, or to maintain a large wound cavity and free opening for later treatment. A gauze drain may consist of (1) a wick or strip of fabric, at times surrounded by a thin layer of elastic rubber (*cigarette drain*) or of rubber tubing to prevent adhesion, or of (2) a large gauze packing used to distend and press upon the walls of the wound which is left widely open.

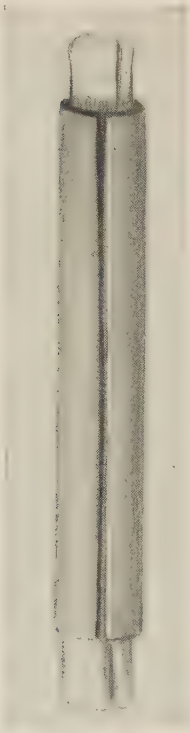


Fig. 21.

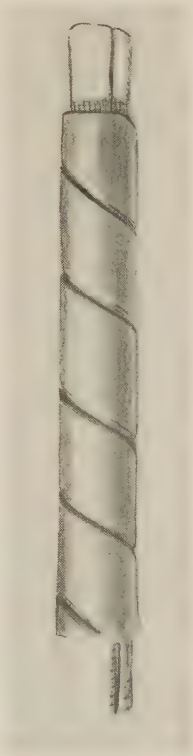


Fig. 22.

Fig. 23.

Fig. 21.—Cigarette drain, formed of split rubber tube containing gauze.
Fig. 22.—Drain formed of a spirally cut rubber tube containing gauze.
Fig. 23.—Cigarette drain formed by encasing a loose roll of gauze in rubber dam.

Mikulicz's drain or *tampon* is a useful massive gauze drain. A large square or rectangular piece of gauze is first used to line the wound. Into this lining or bag continuous or interrupted strips of gauze are packed, the ends being brought to the outside. The bag localizes the gauze introduced, facilitates removal, and prevents the overlooking or retention of a strip of gauze where many pieces are used. To aid in the removal of the outer square of gauze a strong thread may be tied to its center and brought out through the dressings.

Gauze used for drainage may be plain, or medicated by iodoform, aristol, or other drug. The number and character of all drains introduced at an operation

should carefully be recorded and drains should be thoroughly inspected on removal that no portion be left in the wound. Drainage is facilitated if moist, wet, or ointment dressings are placed over the ends of the drain.

The Carrel-Dakin Treatment.—*Dakin's solution* is a solution containing not less than 0.4 per cent., or more than 0.5 per cent. of sodium hypochlorite, alkaline to an alcoholic solution of phenolphthalein, but not alkaline to powdered phenolphthalein. If the percentage of sodium hypochlorite is below 0.4, the antiseptic power of the solution is insufficient; if greater than 0.5, the solution is too irritating. If acid, the solution is unstable; if alkaline, it is irritating. The percentage strength of the sample of Dakin's solution is tested by determining the number of cubic centimeters of decinormal sodium thiosulphate solution which are required to decolorize 10 c.c. of the diluted solution, containing 10 c.c. of a 10 per cent. solution of potassium iodid and 5 c.c. of glacial acetic acid. The number of cubic centimeters of the thiosulphate solution required is multiplied by the factor 0.03723, which gives the percentage of sodium hypochlorite. The solution is prepared from bleaching powder (chlorid of lime) or chlorin gas. The commercial bleaching powders contain from 0 to 40 per cent. available chlorin.

Dakin's solution is unstable, and is rapidly decomposed by sunlight, contact with organic matter, or on standing. It should be used within forty-eight hours after being made, and should be kept in dark bottles protected from the light.

The *Carrel-Dakin treatment of wounds* consists in: (1) Mechanical cleansing; (2) chemical cleansing by Dakin's solution; (3) bacteriologic control, and (4) closure of the wound.

There is installed into the wound (after thorough mechanical cleansing) a hydraulic system of small, soft-rubber tubes, perforated at intervals from the closed extremity, so arranged that the fluid will flow equally from each opening. The wound is freely irrigated once every two hours during the night and day with Dakin's solution. Wounds are dressed daily, using sterile forceps, sterile sponges, and absorbent cotton. The surface of the wound and the surrounding skin are first washed with a neutral solution of soap (as oleate of soda) on sponges of absorbent cotton; this is washed off with sterile water, the surface dried by a gauze compress, and the surrounding skin protected by the application of gauze sterilized in yellow petrolatum. Dressing pads are placed under the limb, perforated tubes of the proper size are so arranged in the wound that every part will be irrigated, over which loosely fluffed gauze is placed, and the dressing pads closed over the wound. The opening in the tubes are 1 mm. in diameter at intervals of 1 cm. To prevent the tube from slipping upon a smooth wound surface the tubes are, at times, covered with Turkish toweling. Dressing pads are made of a layer of gauze, a thin sheet of absorbent cotton, a thick sheet of non-absorbent cotton, and a sheet of gauze. The vaselin compresses measure 9 by 17 cm. and are impregnated with: yellow petrolatum, 91 parts; resin, 3 parts; and paraffin, 6 parts.

Dakin's solution dissolves pus and pus-clots, but not blood or blood-clots. It destroys silk and catgut, but not linen thread.

Treatment of Small Penetrating Wounds: (1) Resection of surrounding skin. (2) Wide opening parallel with the direction of the underlying muscles. (3) Resection of the deep soft tissues, and removal of foreign bodies and completely detached portions of bone. (4) Cleansing of the wound with neutral soap solution on cotton sponges. (5) Complete hemostasis. In the first twenty-four hours the wound is immediately closed; after twenty-four hours Dakin's solution is instilled every two hours, and if, after twenty-four hours of this treatment, smears from the wound show less than one bacterium to 5 or 10 fields, delayed primary closure is performed. One micro-organism to 5 or 10 fields indicates surgical sterilization. The action of the Carrel-Dakin solution is prevented by the interposition of blood-clot or gauze. For surface wounds a loop tube or tube covered with Turkish toweling is used; the toweling becomes clogged in two or three days and should be changed. For seton wounds a through-and-through perforated tube is employed; for multiple wounds many tubes in various directions are used with gauze between the tubes, but not between the wound and tube. The gauze is used to keep the tubes in contact with the tissues. Turkish-toweling tubes should not be used in a purulent wound. Fresh forceps are used for each wound.

Dichloramin-T does not dissolve necrotic tissue as does Dakin's solution, but is useful for superficial wounds; not so useful in deep, badly infected wounds. To prevent irritation light porous dressings should be used. Dichloramin-T decomposes rapidly in the light, setting free hydrochloric acid. It is used, dissolved in chlorinated eucalyptol or chlorcosane, in strengths of 5 to

25 per cent. It is impossible to sterilize an infected wound by dichloramin-T or Dakin's solution as long as there is dead tissue or blood-clot present.

In chronic wounds of soft tissues and bones the infection only extends to a depth of 2 or 3 mm. from the surface of the wound.

Application for Gunshot Wounds: First twenty-four hours (pre-inflammatory period), careful débridement, cleansing and closure give good results; *after twenty-four to forty-eight hours* (inflammatory period), if the part is gangrenous, immediate excision or amputation is indicated; if the part is phlegmonous, or actively inflamed, septicemia often follows operative intervention, and only simple incisions and superficial cleanliness should be used. *Third stage* (suppurative stage) is associated with a developed tissue resistance and operative intervention is fairly safe.

Primary wound closure should only be attempted by an experienced surgeon working with adequate facilities, under conditions which will enable the wound to be watched for at least ten days after the operation. Wounds closed before the eighth day heal with little scar-tissue formation. Before the twelfth day the skin is not adherent to deeper structures.

Operation in Infected Compound Fractures: (1) For the first twenty-four hours, thorough intervention. (2) During the first three weeks of suppuration operation is dangerous. (3) After one month, and with formation of callus and beginning consolidation of bone, operation for an infected fracture may cause a secondary septicemia. (4) In the late stage of fistulization operation is not dangerous, but it is better to await the formation of the sequestrum.

Under Dakin's solution the wound secretion should become sticky, yellowish, and transparent (chlorinated secretion), and the granulations red, smooth, firm, and regular. Pus should not be present.

Vaccines.—*Topovaccination* consists in the application of vaccines locally to infected wounds. With an open wound, a strip of gauze impregnated with the vaccine is introduced. Polyvalent vaccines are used where the causal organism is not known. Without open wounds, as in furunculosis, the vaccines are applied to the surface. A streptococcic vaccine is useful in erysipelas.

Secondary Complications of Wounds.—Infection of the wound is indicated by local pain and throbbing, chilliness, rise in temperature, increased pulse-rate, leukocytosis, redness, induration, swelling, and tenderness about the wound. The stitches should be removed, and the lips of the wound separated sufficiently to obtain drainage, and wet antiseptic fomentations (as 1 : 4000 sublimate solution, or 2 per cent. aluminum acetate) applied. Tincture of iodin, diluted one-half and instilled in the wound, is antiseptic and locally stimulating and may arrest the inflammatory process. In mild and early cases, where there is only slight tenderness and induration about the wound, a continuous coating of the ointment of yellow oxid of mercury, with relief from tension by the removal of constricting sutures, often suffices.

Delayed healing due to the size of the wound may be overcome by skin-grafting or plastic operation. If there is sufficient adjacent tissue for closure without tension, the granulating surface is sterilized by the application of a saturated solution of chlorid of zinc for five minutes, excised, the adjacent skin mobilized and sutured.

Secondary contracture of scars may lead to much deformity, with alteration in shape of the soft parts and bones. The contractures are treated by division or excision of the scar, with skin-grafting or plastic operation.

For infected wounds treated after twenty-four hours: (1) Wet antiseptic dressings; (2) Carrel-Dakin treatment, or (3) cleanse with alcohol, rub with "bipp."

Keloid is a vascular, fibroid mass developing in scars, especially in negroes.

It often recurs after excision, and develops even in the scars produced by needle punctures. *Treatment:* Excision and suture, followed by radiation to prevent recurrence.

Disfiguring scars may be excised, the adjacent skin being mobilized and very accurately sutured. The operation should not be attempted until at least three months have elapsed after evidence of wound infection or irritation. To prevent thickening of the scar, carefully supervised exposures to filtered Roentgen rays are used.

Slight irregularities of the skin may be smoothed by (1) blistering with cantharidal collodion, (2) a surface cauterization by the momentary application of liquefied phenol, followed by alcohol, or (3) by trichloracetic acid applied and washed off in three to five minutes.

INJURIES AND DISEASES RECEIVED FROM LOWER ANIMALS

Mammals.—The large quadrupeds may cause serious lacerated, contused, or punctured wounds by biting, goring, clawing, or stamping the man attacked. The enraged elephant may tear a great lacerated wound, or inflict a crushing fracture by impact of the trunk. Again, the unfortunate victim is gored, lain upon, sat upon, and rubbed into the ground or torn limb from limb. Few survive attempts at goring and crushing, as did Carl Ackley.

The larger carnivora of the tropics, including the lion, tiger, and leopard, living upon more or less contaminated meat, carry violent and often fatal infection by fang and claw. The mortality from sepsis following these wounds is high, and every effort should be made to prevent infection by filling the wounds with tincture of iodin, a solution of potassium permanganate or other antiseptic, and by early débridement. In contrast, the wounds by North American bears in their native environment often heal without infection, and death from sepsis is unusual. Serious infection rarely follows bites by the great Alaskan brown bear, the largest carnivorous animal now living. Not infrequently these bites involve the deeper tissues or joints, yet heal with little surgical attention, and without serious infection. A man treated by Dr. Baughman, and Dr. Romig of Seward, had 56 bites involving the outer layer of the skull, muscles of the back of the neck, the posterior thorax, buttocks, scrotum and leg, which healed without sepsis. In the excitement of the encounter the man may have no sense of pain. Livingston, after being mauled by a lion, and Dr. Charles Penrose, bitten over 30 times by a grizzly, wrote that the laceration of tissue was painless.

The possibility of the inoculation of hydrophobia from the bite of a dog, cat, wolf, or skunk should always be considered. The horns of ungulata are responsible for deep and badly lacerated wounds. The great danger and the number of deaths from semidomesticated deer or buffalo in enclosures are not generally appreciated. However, in a patient treated at St. Mark's Hospital in Salt Lake City, the horn of a Texas steer entered the larynx and emerged beneath the eye, tearing through the hyoid and inferior and superior maxilla without fatality; and a third of a century ago Harris published statistics indicating that it was, at that time, safer to have a cesarean section performed by the horn of an enraged bull than by the surgeon.

Rats transmit plague, hemorrhagic septicemia, rat typhoid, pseudotuberculosis, rat-bite fever. Two per cent. of rats carry virulent bacteria in the intestinal tract.

Pisces.—Terrific lacerations, amputations, and abdominal wounds are caused by the teeth of sharks, barricuda, and other fish. Roosevelt called attention to piranhas, the small, but very aggressive carnivorous fish of the inland waters of South America, quite capable of causing the death of a man or large mammal.

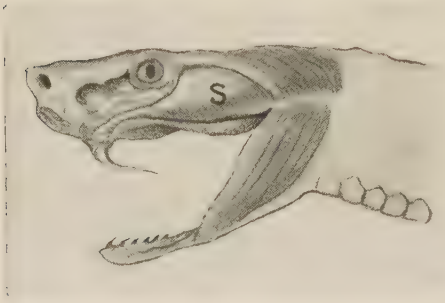


Fig. 24. -Head of venomous snake showing connection of the poison glands with a hollow erectile fang in the upper jaw.

Snake Bite.—All snakes possess glands secreting poison, situated about the head, and resembling the parotid salivary glands. In the majority of snakes these are rudimentary or are without outlet. The bites of non-poisonous snakes are rarely serious, nor is the bone-crushing force of the larger constrictors often felt by man. In North America there are only four venomous snakes. Three of these—the *rattle-snake* (genera *Crotalidæ* and *Sistrurus*), the *copper-head* (*Ancistrodon contortrix*), and the *water moccasin* or *cotton-mouth* (*Ancistrodon piscidoris*)—belong to the pit vipers (genus *Crotalidæ*), distinguished by a deep depression between the mouth and eye. The other is the small, brilliantly colored *harlequin* or *coral-snake* (family *Elapidæ*), occasionally found in the Southern United States. None of these snakes is very aggressive and the coral- and rattle-snake rarely bite except under marked provocation. In India and Ceylon the cobra (Naji naji) and krait are found, most dangerous of serpents, and responsible for over 20,000 deaths yearly. The very poisonous *fer de lance* (*Bothrops lanceolatus*) and the "*bush master*" are found in the West Indies. In Europe there are various vipers, and in Egypt is found the *Egyptian asp* (*Naia hage* and *Cerastes*), *Vipera hasselquistri*, the reputed cause of Cleopatra's death. Spitting snakes (as the *black-necked spitting cobra*, *Naia nigricollis*) that eject a blinding venom for a distance of several meters inhabit Africa and other tropical countries.

Fig. 25.—Head of rattle-snake: *a*, Characteristic pit of the pit vipers.

Snake venoms have been studied by Weir Mitchell, Reichert, Calmette, Phisalix and Bertrand, Fraser, McFarland, and others. The poison—which is discharged through two grooved or hollow, fixed (cobra) or erectile (rattle-snake) teeth in the upper jaw, which communicate by ducts with the glands

secreting it—contains globulin, albumoses, and peptone. It affects (1) the *central nervous system*, causing convulsions and paralysis (the dominant action of cobra venom); (2) the *blood*, with hemolysis and blood destruction, and (3) *local tissue*, causing great swelling and local destruction of tissue (the dominant action of rattle-snake venom).

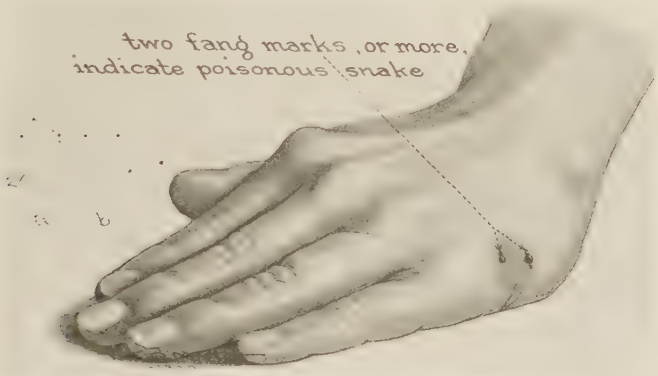


Fig. 26.—Bite of poisonous snake. Marks of the larger, hollow or grooved fangs of the upper jaw (1) are evident. Minute punctures from the small teeth of the lower jaw (2*a*, *b*) may or may not be present.

Bite.—Non-poisonous snakes produce four rows of punctures. The poisonous fangs usually cause two relatively large openings. New teeth erupt as the fangs are lost.

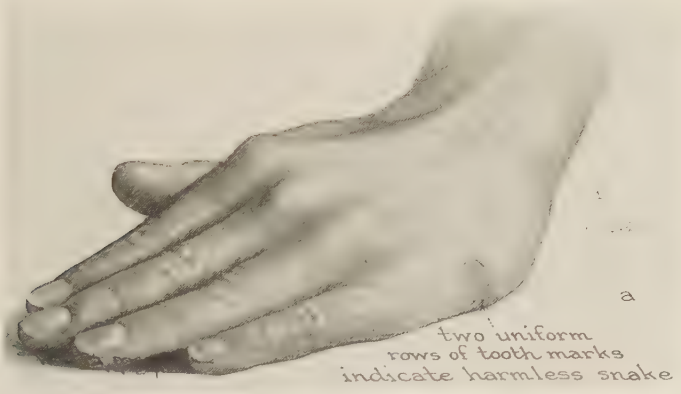


Fig. 27.—Bite of a non-poisonous snake: (1) Punctures from the teeth of the upper jaw; (2) from those of the lower jaw.

Venoms.—1. *Neurotoxin*, the predominant principle in colubrine (cobra, krait) venoms, causes spreading paralysis of the central nervous system with drowsiness, incoördination, staggering gait, drooping head, motor paralysis, difficult and incoördinate speech, glossopharyngeal palsy, ptosis. The pupils, at first normal, dilate with the development of asphyxia. Salivation, swollen tongue, vomiting and involuntary ejections occur, with rapid, shallow respira-

tions and, at times, convulsions. Death results from asphyxia. The pulse is good until late, and the heart continues after respiration has ceased. There is little local swelling or pain, but an early local numbness.

2. *Hemorrhagin*, the thermolabile substance predominating in viperine venoms (rattle-snake, viper), causes agonizing local pain, oozing of blood, enormous swelling, cytolysis, thrombosis and hemolysis, and extensive necrosis and gangrene. Subcutaneous and internal hemorrhages may occur, with epistaxis, hematuria, melena. The pulse is weak, the pupils dilated. Death occurs early from vasomotor paralysis and cardiac failure, or later from necrosis and septic complications in the injured area.

Symptoms depend upon (1) the variety of snake; (2) the size of the snake, and the amount of poison injected; (3) the situation of the bite—if in a vascular area (face) or blood-vessel, the effects are much more rapid and intense than if in an avascular part (adipose tissue); and (4) the size and general resistance of the person bitten.

Prognosis.—Forty per cent. of all cobra bites, 16 per cent. of rattle-snake bites, and occasionally moccasin bites are fatal. The bite of the European viper or copper-head rarely causes death, except in a child. The cobra bite is fatal in from one to two hours and, when a vessel of the face is injected by the venom, death has occurred in from two to six minutes. Rattle-snake bites are rarely fatal except after several hours or days, although Mitchell and Reichert record one death within forty minutes.

Treatment.—1. *Localization of the Poison:* A tight band should be immediately placed around the limb above the bite, and as much of the poison removed from the wound as possible by suction, excision, or by amputation.

2. *Local neutralization* by the injection of a 1 per cent. solution of calcium hypochlorite, a 1/10 of 1 per cent. solution of chlorid of gold, or a 1 per cent. solution of potassium permanganate in the adjacent tissues and the filling of the wound with permanganate crystals. For the intense local irritation and swelling which may progress and arrest the circulation, causing necrosis and gangrene (rattle-snake), multiple incisions should be made through the deep fascia, and the wounds packed with gauze wet with a saturated solution of permanganate.

3. *Antivenene:* The most efficient treatment is the antitoxin or antivenene developed chiefly by Fraser and Calmette. The serum is obtained from horses that have been immunized by progressive injections of the venom. Antivenene is to a degree specific, so cobra antivenene should always be used for cobra bite. The injection of antivenene within one-half hour of the time of a cobra bite usually prevents death. Antivenene is less effective against venoms like that of the rattle-snake which produces local destruction of tissue. Venoms are decomposed by the digestive juices, and are harmless when swallowed.

4. *General treatment* includes rest, supportive and eliminative measures, alcohol being avoided for its depressing effect on the respiration.

Insecta.—Insects may serve as carriers of parasites, or may be injurious through their bite, venom, or their invasion of tissue. The larvæ of various insects may develop upon or within the body, from eggs deposited upon the person, or within the cavities of the body, or upon the food. From eggs de-

posited upon the skin or in wounds by the *common fly*, maggots develop. Larvæ of various insects hatch in the nasal passages, the accessory sinuses, the ear, eyes, intestinal tract, vagina, or a wound. From eggs accidentally contained in gluten suppositories, Walsh records the development of the large grub of the meal worm in the rectum. *Caterpillars* cause severe erythema and urticaria through poisonous cutaneous hairs. The irritation of the *procession caterpillar* (*cnephocampa*) of Europe is notorious, and urticaria may result without direct contact. Rarely, lepidopterus larvæ have been found in the intestinal contents.

Diptera.—Most of the parasitic larvæ belong to the family of flies. The ova of the *blue-bottle fly* (*Musca vomitoria*), the common *flesh-fly* (*Creophila*), the *bot-fly* (*Gastrophilus equi*), and of other flies may be deposited in wounds, in the nose, the external ear, the conjunctiva, the vagina, and develop into larvæ that cause serious lesions. The presence of maggots in the body is more common in the tropics, and especially in persons of unclean habits. More or less local irritation may be produced by bites of *horse-flies* (*Stomyxes* and *Tabanus*). After ingestion of the eggs of the common house-fly, the blue-bottle fly, or the flower-fly, the larvæ may set up a marked irritation in the intestinal tract.

Myiasis is a term applied to the disease due to the larvæ of certain flies. The eggs of the fly are deposited upon the skin or mucous membrane, and after a few days the larvæ emerge, enter natural passages, or bore into the skin or subcutaneous tissue. The *screw worm*, the larva of a blue-bottle fly, (*Musca macellaria*) found in South America, the Southern United States, West Indies, and Cochin China, is whitish, about 14 mm. long, with ridges giving a screw-like appearance. On the skin a pustule or boil is produced; in the nose or ear the larvæ burrow through mucous membrane, muscle, cartilage, even to the meninges and brain. In 67 patients there were 30 deaths. Large, ulcerating, fungating, offensive masses containing larvæ may be formed.

Ver du Cayor, the larva of the *Cordylobia anthropophaga* or *Tumba fly* of Africa, has twelve segments, is about 12 mm. long, and burrows beneath the skin. Tumbu-fly abscess occurs chiefly upon the buttocks, thigh, axilla, or arm, producing a painful boil containing grayish-white larvæ.

Ver macaque, the larva of a gadfly (*Dermatobia cyaniventras*), occurs in Central America, Mexico, and Brazil. The club-shaped or worm-shaped maggot burrows into the tissues, and forms large painful abscesses (*gadfly boils*) which discharge a seropurulent fluid showing the black feces of the larvæ.

Treatment consists of prophylaxis (screening against flies) and the protection of wounds by occlusive dressings. The parasites may be removed from the normal sinuses or wounds by syringing with chloroform water, 5 per cent. of chloroform in milk, or solutions of carbolic acid, creolin, or by mechanical removal with forceps. After tobacco juice is applied to the opening the larvæ may extrude, when they may be grasped and extracted. Large worms in the nasal sinuses or ear may be killed by the vapor of ether, or by injecting ether through a fine hypodermic needle into the body of the worm.

Siphonaptera.—The fleas are suctorial, wingless insects possessing great leaping power, and are closely related to the Diptera. While each kind seems to have a particular animal as its normal host, fleas often, for a temporary

period at least, migrate to other species of animals. Thus, the *hen flea*, the *rat* and *mouse flea*, or the *dog* and *cat flea* may affect man. The common *house flea* (*Pulex irritans*) is distinguished from those of the dog and cat by the absence of spinous combs about the head. The *jigger flea* or *Chigœ* is found in tropic and subtropic regions, infesting the lower animals and man. After impregnation, the female burrows into the skin, especially in the sole of the foot and about the toe-nails, producing a vesicular and pustular inflammation. If the insect's greatly distended body is ruptured within the tissues, liberating larvæ, serious inflammatory changes follow. With the presence of fleas, particular care should be taken in repeatedly cleaning and removing all dust and litter from the floors of dwellings, stables, and hen-houses. Sprays or washes with solutions of pyrethrum, carbolic acid, creolin, kerosene, and the newer volatile insecticides (Flyosan) are useful.

Hemiptera.—These are suctorial insects living upon the juices of animals and plants. The *bedbug* (*Cimex lectularius*) and various pediculi or lice *Pediculus capitis*, *Pediculus corporis*, and *Pediculus pubis*) are the main varieties of the hemipterous insects that infest man. The liquid secreted by the crab-louse is said to cause navy-blue spots (*taches bleuatres*) upon the skin.

Lice may be acquired from contact with infested persons, clothing, or utensils. Bedbugs are found on domestic fowls, pigeons, swallows, and bats, and are distributed over most parts of the globe.

Idiosyncrasy greatly influences the degree of reaction to their bites. The so-called *giant* or *big bedbug* (*Conorhinus sanguisuga*) is a much more formidable insect, found throughout the Southern United States and South America. The adult forms are winged. The bites may be followed by serious inflammation. Certain of the volatile insecticide sprays (Flyosan) are very effective against bedbugs. Itching is relieved by the application of compound sulphur ointment.

Arachnidia.—Many of the spiders and scorpions are venomous, especially the *tarantula* and the small *black spider* with red spots. The *itch-mite* (*Sarcoptes scabiei*), which invades the body, is the cause of scabies or itch. The minute parasites, *Demodex* or *Acarus folliculorum*, often found in the sebaceous follicles especially on the nose, have little pathogenic action.

Ixodes.—The ticks or wood-lice attach themselves to man or beast from grasses or shrubbery which they inhabit. They fill themselves with blood and may transmit disease.

Boöphilus bovis is a carrier of "Texas cattle fever." The bites of the *Argas persicus* of Persia and the *Argas moubata* of Portuguese South Africa are often followed by serious febrile illness, apparently due to the inoculation of a parasite. To prevent their bites, houses may be fumigated by burning pyrethrum. Beds should be placed above the ground and rooms should be carefully screened.

Linguatula rhinaria (*Pentastomum tænioides*) is found in portions of Europe, and in the adult form invades the nasal sinuses. It is rare in man, being more common in dogs, and occasionally is found in horses. The larval form (*Linguatula serrata*, *Pentastomum denticulatum*) occurs in the liver, spleen, and sometimes the kidneys.

Harvest Bug, Red Bug, or Red Flea (Leptus Autumnalis).—The larva of the *Trombidium holostricum* is a minute reddish parasite, which burrows be-

neath the skin, especially about the wrist, thighs and legs, producing a pustular lesion with intense itching. It may be destroyed by the application of sulphur or mercurial ointment.

Rickettsia (*Howard Taylor Ricketts*) embraces a group of micro-organisms which may be pathogenic, found in arthropods, as the *dust-louse, cat flea, bed-bug*, certain *ticks*, including the micro-organismal cause of *typhus, trench fever, Rocky Mountain fever* and, possibly, *wood-tick paralysis.*

Wood ticks (*Dermacentor denustus* or *Dermacentor occidentalis*) are found in the Rocky Mountains of the United States and Western Canada, in South Africa and Australia. After remaining attached to the skin of children for several days, they produce a local reaction, with petechia or necrosis, and occasionally paralytic symptoms with general marked weakness of the voluntary muscles, and slight febrile reaction (*wood-tick paralysis*) which disappears in forty-eight hours after the wood tick, commonly found on the scalp, axilla or skin fold, has been removed. The *wood-tick season* is from February to August.

In *Rocky Mountain fever* the tick serves as an intermediate host. The disease occurs at high altitudes during the spring and early summer months. Following the embedding of the insect in the skin, there is chill and fever, muscular pain and aching which, after an intermission, is repeated for a number of times with later development of bright red macules upon the skin from minute hemorrhages, or petechiæ. There is enlargement of the liver, reduction in hemoglobin, albuminuria, and slight leukocytosis.

Prognosis.—The disease runs its course in two weeks, but death from complicating renal, pulmonary, or cardiac conditions produce a mortality of from 2 to 30 per cent.

Swine fever occurs from the handling of the tissues of living or dead hogs infected by swine fever. After an incubation period of twelve to seventy-two hours, the fingers and hands become swollen, bluish-red in color; painful, tender nodules develop, and enlargement of the tributary lymphatic glands occurs.

Annelida.—Of the leeches, certain forms are aquatic and attach themselves to the skin of animals that enter the water. Other forms are found on bushes and grasses from which they spring upon passing animals. Of the latter, the *Hemadipsia* (*Hirudo ceylonica*) of Ceylon and parts of South America are the most important. Not only may the bite cause painful ulceration, but death has occurred from many repeated, small bleedings. In Southern Europe and Northern Africa the *horse leech* (*Hemopis sanguisuga*) is found, and may invade the nasal chambers, the trachea, or larynx, producing severe pain and repeated hemorrhage. The leech may gain entrance to the body through foul drinking-water. By boiling or filtering all drinking-water, and by protecting the surface of the body, leeches may be avoided.

Helminthes.—*Vermes* (*worms*) parasitic in men comprise (1) the *nematodes* or *round-worms*, (2) the *trematodes* or *sucking worms*, and (3) the *cestodes* or *tapeworms.*

1. **Nematodes.**—(a) *Round-worms* (*Ascaris lumbricoides*) occur chiefly in the small intestines, often causing no disturbance. Occasionally they migrate into the stomach, biliary passages, appendix, mouth, nose, eustachian tube or through the intestinal wall, producing obstruction, inflammation or peritonitis.

Again, trouble may result from the absorption of toxic substances produced by the worm, or from intestinal obstruction, the worms having collected into a compact ball.

(b) *Thread-*, *pin-*, or *seat-worm* (*Oxyuris* or *Ascaris vermicularis*) occurs in the colon and rectum of children and occasionally in adults. It is frequently found in the vermiform appendix and, through abrasions of the mucous membrane, may be an exciting factor in appendicitis.

(c) *Uncinaria* (*Anchylostoma duodenalis* or *hook-worm*) affects chiefly miners, tunnel makers, brick makers, diggers, farmers, and others who are in contact with the soil, especially in the Southern United States. Infection occurs through the skin about the feet and ankles, especially in those going barefooted, producing *ground itch*. The adult worm lives in the duodenum, puncturing the mucous membrane and sucking blood, first at one point and then at another, with resulting anemia of high degree: *miner's anemia*, *brick-maker's anemia*, *tunnel anemia*, and *uncinariasis*. The diagnosis is made by finding the eggs in the stool. To avoid infection, persons should not go barefooted on contaminated soil.

(d) *Whip-worm* (*Trichuris trichiura*, *Trichocephalus dispar*) occurs in large numbers in the intestines of Europeans and Asiatics. It may be responsible for anemia and diarrhea. Apparently it is of limited surgical importance.

(e) *Trichinella* (*Trichina spiralis*, *trichinosis*) enters the alimentary tract in a larval form, encysted in diseased or measly pork. Within a few days it develops to maturity, and then gives rise to broods of embryos which invade the tissues and enter the voluntary muscles, where they become encysted and may retain their vitality for fifteen or twenty years. They produce early severe intestinal disturbance, eosinophilia, and secondary tenderness of the voluntary muscles. The condition may be mistaken for typhoid fever, acute muscular rheumatism, or myositis.

(f) *Guinea-worm*, thread-worm of Medina (*Dracunculus* or *Filaria medinensis*), undergoes intermediate existence in certain fresh-water crustacea and develops in the subcutaneous tissues of man, where it may obtain a length of from 60 to 100 cm., and produce marked local irritation and, at times, abscesses. It is usually removed by securing the extremity of the worm which is near the surface of the skin, and coiling it upon a small stick. By slowly turning the stick, the worm may be gradually extracted without rupture. Should the body of the worm break beneath the skin, the liberation of embryos and possibly toxic substances is followed by severe local reaction and abscess formation.

(g) *Filaria* live in the blood- and lymph-vessels under the name of *Filaria sanguinis*. The four principal varieties are the *Filaria nocturna* (*Filaria bancrofti*), the *Filaria diurna* or *loa*, the *Filaria perstans*, and the *Filaria demarquaii*. The *Filaria diurna* is usually found beneath the conjunctiva. The *Filaria perstans* is responsible for the dangerous *African lethargy* or *sleeping sickness* of the Congo, being spread by the *tsetse fly*.

2. **Trematodes or Flukes.**—(a) *Schistosomiasis* (*Bilharziasis*) is a disease chiefly occurring in Egypt, caused by the *Schistosoma* or *Schistosomum hæmatobium* (*Distoma hæmatobium* or *Bilharzia hæmatobia*). The adult lives in the blood and produces eggs with pointed spurs that lead to ulcers in the walls of

the capillaries, and frequently cause endemic hematuria (in Egypt) with papillomatous growths and calcareous deposits in the urinary bladder. The worms are found chiefly in the portal system and may give rise to intestinal hemorrhage, the disease often persisting for many years.

The trematodes of the genus *Schistosoma* enter through the skin, mucocutaneous or mucous surfaces, and, after an incubation period of five to eight weeks, cause toxemia with fever, urticaria, enlargement of liver and spleen, and urinary and intestinal irritation. After about three weeks this is succeeded by symptoms from localization of the worm. The ova are excreted by the urine and feces. The disease is chronic, may last twenty or thirty years, and the local infection predisposes to carcinoma.

Varieties.—(1) *Schistosoma hæmatobium* (*Bilharzia hæmatobia*): Genito-urinary schistosomiasis is found in Africa, on the East Coast, and occasionally in Arabia, Persia, and Mesopotamia. (2) *Schistosoma mansoni* (*Bilharzia mansoni*): Intestinal schistosomiasis is found in Africa and parts of South America. (3) *Schistosoma hæmatobium* (*Schistosoma mansoni*): Mixed schistosomiasis is found in the Deltaic regions of Egypt. (4) *Schistosoma japonica* (*Bilharzia japonica*): Eastern schistosomiasis, Katayama disease.

Genito-urinary schistosomiasis is associated with hematuria, urinary retention, cystitis, ascending urinary infection, granulomatous cysts, papilloma, urinary calculus, and the passage of ova in the urine. In the *bladder* papules occur, which coalesce, forming confluent masses with catarrhal inflammation, thickening of mucosa, polyps of sessile or pedunculated form, and discharge of mucus. Secondary epitheliomatous change is not uncommon. The ova penetrate through to the intracellular space between the mucous glands. The egg-shells become chitinous, causing sandy patches on the bladder wall (which are seen on cystoscopic examination), and vesical calculi form. In the *ureter*, small submucous cysts develop, and obstruct the lumen with secondary hydronephrosis, pyonephrosis, abscess of the kidney, and septic nephritis. The *kidney* is rarely affected directly, although minute abscesses of the cortex occur. In the *prostate*, *seminal vesicles*, and *urethra* abscesses and fistulæ form. A secondary hard infiltration in the substance of the penis occurs, with ulceration of the meatus, and granulomatous and papillomatous outgrowths.

In women the papillomatous growths may involve the cervix, also, with concretions or calculi in the urinary tract.

Diagnosis is made by the presence of the ova in the urine, and by cystoscopic examination.

Treatment consists of intravenous injections of tartar emetic, emetin by mouth, and the use of urinary antiseptics, diuretics, and sodium phosphate to alter the alkaline urine. Irrigations of the bladder with permanganate of potash or silver nitrate solutions are of value and, for hemorrhage, injections of adrenalin chlorid are used. Vesical calculi should be removed.

Intestinal schistosomiasis (*schistosomiasis mansoni*) affects the mesentery, rectum, and intestinal canal, and in the early stages causes a general toxemia.

Pathology.—A diffuse infiltration of the submucosa, with catarrhal inflammation (*bilharzial colitis*), chiefly affecting sigmoid, colon, mesenteric glands, liver, pancreas, and spleen. Later the mucous membrane becomes yellowish,

due to calcification of the large number of ova deposited. The mucous glands undergo hyperplasia, and sessile pedunculated adenopapillomas develop, which may become detached by ulceration. The liver becomes cirrhotic, but retains a smooth surface, and the contained connective tissue occasionally shows a characteristic pigmentation.

Symptoms.—Bilharzial infection begins with urticaria, rash and fever, followed by colitis and the passage of blood-stained mucus and ova in the feces. Proctoscopic examination shows an infiltrated mucous membrane, dull red papules, ulcers, and papillomas. Bilharzial fistulæ with ulceration, scarring, granulomas, and papillomas, occur about the anus with, at times, rectal prolapse.

Treatment.—The use of intravenous injections of tartar emetic should precede all other treatment. For resistant types, intestinal antiseptics, rectal irrigations and the rectal or abdominal removal of papillomas may be required.

(b) *Fasciola hepaticum* (*Distoma hepaticum*) is a fluke inhabiting the biliary passages, giving rise to ulceration, icterus, and severe hepatic disturbances which may end fatally. The ova may be found in the stools.

(c) *Distoma westermanni* is a bronchial fluke which is the cause of epidemic, parasitic hemoptysis occurring in China, Japan, and Formosa.

3. **Cestodes or Tapeworms.**—(a) Of chief importance surgically is the *Tænia solium* (the *armed* or *pork tapeworm*), the measle of which exists in the flesh of swine, the adult in the intestine of man. Occasionally, from the ingestion of the eggs, the measle (*Cysticercus cellulosæ*) invades the human muscles or internal organs, and produces cysts. The *Cysticercus* is found in the brain, heart, and other internal organs. (b) *Tænia echinococcus* (causing *hydatid cysts, echinococcus cysts*) is a minute tapeworm of four segments, with four suckers and a double row of barbed hooklets, the adult form of which lives in the upper small intestine of the dog, wolf, and jackal, but never in man. The intermediate larval form produces hydatid cysts in man, hogs, sheep, and oxen. The length of the adult is 5 mm. Hydatid disease is prevalent in Australia, Iceland, Germany, Central Europe, Italy, and other countries, but is not indigenous to the United States.

Ova from the terminal segment of the adult worm, discharged in the dog feces, on entering the stomach of man develop, and the six-hooked embryo leaves the egg, penetrates the intestinal wall, and passes with the portal circulation to lodge in: the *liver* in 60 per cent.; the *lung* in 10 to 15 per cent.; or, less frequently, the *kidneys*, *spleen*, *omentum*, *heart*, *brain*, or *bones*. On lodgment a painless cyst which may reach great size develops, with an external capsule formed by the adjacent connective tissue. The true capsule has an external elastic and an inner parenchymatous or germinal layer containing brood capsules of scolices, on the inner or outer surface of which multiple scolices or embryos develop. There is, therefore, a chitinous layer or the *ectocyst*, an internal parenchymatous layer (*endocyst*), and the surrounding condensed fibroconnective tissue from the host. From the endocyst, secondary cysts (*daughter cysts*), resembling the primary cyst, arise. They may be endogenous, developing within, or exogenous, developing without, the primary cyst. The fluid in the cyst is clear, like spring water, without albumin, with a specific gravity of 1.005 or 1.010, and contains chlorids and barbed hooklets. The cysts progress

and grow, degenerate, die and calcify; rupture, disseminating the parasites, or suppurate.

Symptoms are often absent. Again, there is a dragging pain, pressure symptoms, eosinophilia and fever, and a round, elastic, fluctuating tumor with hydatid thrill develops in the liver or elsewhere. Rupture may occur into the stomach, intestines, lungs, peritoneum, bile-ducts, pericardium, or vena cava; is followed by urticaria, and frequently is fatal. Suppuration is marked by pyrexia, chills, and fever. If possible the cyst should be removed *en masse*. If this is not feasible, the cysts should be distended with 1 per cent. formalin, iodin, ether, or other parasiticide for five minutes and isolated, the germinal membrane removed, and the cavity obliterated or drained through a large opening by marsupialization. Recurrence is frequent unless great care is taken to prevent dissemination.

Protozoa.—**Infusoria.**—Catarrhal or ulcerative inflammations of the intestinal tract have been attributed to the presence of *Balantidium coli*, *Cercomonas intestinalis*, and *Trichomonas intestinalis*. These parasites may be acquired from hogs or other domestic animals, or from contaminated earth or water.

Rhizopoda. Of chief importance is the *Amœba coli*, an important factor in chronic dysentery and hepatic abscess. It may be acquired from cats or other domestic animals.

Sporozoa. Most important is the *malaria parasite* which has as its definitive host and carrier the mosquito, genus *Anopheles*.

Coccidia occur in oxen, cattle, mice, guinea-pigs, rabbits, salamanders, cuttlefish, and centipedes, and from these animals or from moist earth on which they undergo a developmental cycle they may, in rare instances, be acquired by man, producing growths resembling adenomas in the liver or other organs.

Sarcosporidia occur in the muscles of mice, cattle, and birds, producing minute white cysts. The chief source of human infection seems to be the eating of infected, imperfectly cooked meat.

CHAPTER IV

BURNS AND SCALDS; WAR-GAS POISONING; EFFECTS OF COLD

Burn is the tissue reaction or degeneration resulting from the application of dry heat. *Scald* is the reaction resulting from moist heat or steam. Special forms of burns are also produced by: (1) *Chemicals (chemical burns)*, including caustics, such as acids, alkalies, phosphorus, arsenic, phosgene, iodin, and bromin; (2) *mechanical friction (brush burns)*, as from friction against a rapidly moving belt, rope, wheel, or even ice; (3) *radiant energy*, as (a) *radiogenic* from the Roentgen ray or radium, (b) *actinic*, as the ultraviolet rays from the sun or quartz light; and (4) *electricity*, including the effects of high-frequency currents and lightning.

Pathology.—The tissues involved show reactive inflammation and necrosis, modified by the depth, extent, and intensity of the burn.

Local Effects of Heat.—The local application of heat may result in: (1) Hyperemia. (2) Extravasation of blood-serum with solution of certain cells (vesication). (3) Coagulation of protoplasm (necrosis). (4) More or less complete oxidation, incineration, or carbonization.

General Pathology of Burns.—(1) Hyperemia, serous effusion, and edema involving the central nervous system, lungs, and abdominal organs. (2) Blood changes with marked leukocytosis, hemolysis, and hemoglobinemia with pigmentation of the renal cells from free hemoglobin, lowered blood and urinary chlorids, lessened blood volume, increased protein catabolism (Davidson). (3) Diffuse minute thrombosis, extravasations in the tissues of the body, degeneration of ganglion cells, edema and degeneration of lymphoid tissue, cloudy swelling and localized necrosis of the liver and kidneys, with softening and enlargement of the spleen, probably due to absorbed toxic substances from the burned tissue.

These changes occur in wide-spread superficial burns due, in part, to increased tissue waste, to retained or newly absorbed toxic products, or to bacterial invasion, but chiefly to toxic products generated in the burned area. Besides this, the suspension of function of important secretory or excretory organs (as the skin) may seriously affect the general system.

Metabolic Changes.—There is no acidosis, no increase in the plasma carbon dioxid, therefore alkalies are not indicated. The blood-urea does not exceed 25 mg. per 100, therefore there is no uremia; there is no increase in the nonprotein nitrogen, but there is a concentration of the blood so that the hemoglobin may rise to 125.

Varieties.—*Dupuytren's Classification:* (1) Hyperemia or erythema; (2) vesication; (3) partial destruction of true skin; (4) total destruction of true skin; (5) charring of muscles, and (6) charring of bone.

First Degree.—*Erythema:* Due to scorch or scald, or the application of solid, liquid, or radiant heat at a temperature or duration insufficient to produce

vesication or necrosis. *Sunburn*, *Roentgen-ray* or *radium dermatitis*, *lightning figures*, and *chemical erythema* are terms applied to varieties of the condition.

Symptoms are acute, stinging, burning pain, redness, transitory swelling, moderate edema followed by desquamation of the epidermis, and, often, the later development of freckles or a pigmented area. Permanent pigmentation has followed the use of a mustard plaster.

Second Degree or Vesication.—The papillæ become hyperemic, infiltrated, and exude a clear, yellowish, mucilaginous fluid which raises the epidermis with the formation of vesicles, blebs, blisters, or bullæ. The epidermis is destroyed, the fluid contains pyogenic bacteria (Unna), and, with rupture of the blisters, the sensitive inflamed papillæ with a thin layer of epithelial cells are exposed. The lost epithelium is rapidly re-formed without the production of a scar, but secondary pigmentation or keloid formation may occur. There is severe burning, stinging pain on the infliction of the burn and on exposure of the inflamed papillæ to the air.

Third Degree.—Partial destruction of skin and necrosis of the epidermis and papillæ occur, with the formation of a hard, dry, insensitive, yellow or black

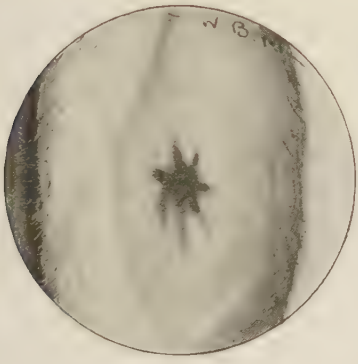


Fig. 28.—First degree burn. Erythema.

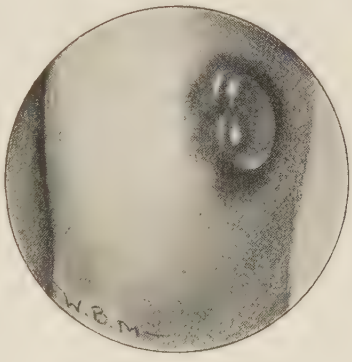


Fig. 29.—Second degree burn. Vesiculation with surrounding erythema.

eschar or slough, which separates in a week or ten days, with repair by secondary granulation. The epithelium is re-formed from the skin margins and the undestroyed sebaceous and sweat glands and hair follicles of the deeper layers of the skin. The burned area is intensely painful for the first and second day, when exposed after protection from the air, and after the separation of the slough. The scar may be slightly depressed. It gradually becomes paler, but does not tend to contract or cause deformity. Pigmentation or keloid formation is common.

Fourth Degree.—Total destruction of skin results from the intensive or prolonged action of the heat, as from contact with a red-hot iron, or prolonged contact of the skin of an unconscious patient with a hot-water bottle at 160° F.

The thoroughly burned area is insensitive, hard, dry, yellowish, brown or black, and like bacon-rind. Through it the underlying pulse or muscular movements cannot be felt. The large deeper eschars separate slowly, in two to three weeks, and granulations then gradually fill the gap. Since the epithelium

is only derived from the margin, many months may be required for complete epithelization if the area is large, unless skin-grafting is used. The resulting scars are inelastic, hard, irregular, deep, furrowed and puckered, with a marked tendency to contract, so that the chin may be pulled to the chest, the teeth and facial bones distorted, the arm bound to the side, the knee or elbow contracted, or the hand greatly deformed. The cicatrices are subject to keloid, recurrent ulceration, and the development of epithelioma.

Fig. 30.—Cicatricial contractures in a child from an extensive burn of the fourth degree following ignition of clothing. Such scars should be removed by plastic operation to prevent malignant change as well as to overcome the deformity.

Fifth Degree.—These burns, involving the muscles (and those of the **Sixth Degree,** involving the bones), occur from prolonged contact with flame, hot metal, steam, or caustics. Such burns result from being imprisoned and burned in a railway or automobile accident, from shoes or boots filled with the nitrohydrochloric acid of a nitrating plant, or from epileptics, drunkards, or other unconscious persons falling in a fire or against a stove. When of the extremities, these burns usually require amputation or an extensive reconstructive operation; when of the trunk, they may involve the large serous cavities, important blood-vessels and nerves.

Symptoms of Burns.—*General:* The *first stage* is characterized by *shock* and *depression* which lasts from thirty-six to forty-eight hours, and if marked, as in extensive and fatal burns, may be associated with a lucid mind and free-

Fig. 31.—Destruction of soft tissues of the back of the hand and contraction following crush and burn of the fifth degree from catching the hand in a heated mangle.

dom from pain. Shock is more intense in children, in burns of the abdomen and trunk, and in burns involving a large surface area.

The *second stage*, of *reaction* and *inflammation*, begins with the recovery from

shock, and continues until the separation of slough, with toxemia, a temperature of 102° to 104° F., and a rapid, full pulse.

It may be complicated by congestions and inflammations of internal organs, such as bronchitis, bronchial pneumonia, pleurisy, meningitis, cerebritis, enteritis, ulceration of the duodenum (Curling's ulcer) with possible perforation, albuminuria (rare), and edema of the larynx from the inhalation of steam or flame.

The *third stage*, of *suppuration* and *exhaustion*, begins with the separation of the sloughs from the seventh to the fourteenth day, and continues until the healing of the wound. This period is marked by toxemia, amyloid degeneration of internal organs, and possible streptococcic or other infection of the wound.

Prognosis.—*Surface area:* An involvement of over one-third of the body surface, even by a very superficial burn, is always serious and often fatal. Children succumb more readily to shock, and adults to prolonged suppuration. Burns over the large serous cavities, as of the abdomen, skull, or thorax, are more serious than those of other parts. Burns of the face, neck, and mouth, with possible involvement of the larynx, are especially serious from secondary edema of the larynx. Death occurs from shock, sepsis, suffocation, or a secondary inflammation of an internal organ, as pneumonia, nephritis, or intestinal ulceration.

Treatment.—*Shock:* The indications are to favor reaction from shock and to relieve pain. The patient should be kept at rest in a hot-air chamber, formed of a bed or cradle containing electric lights and covered by blankets. To relieve pain the part may be painted with 1 per cent. butesin picrate solution, or covered with a layer of lint wet with 1 per cent. procain solution containing 1 ♏ of adrenalin to each ounce. In the first stage the cautious administration of morphin may be necessary. Water, glucose, and salt are given by mouth, rectum, or vein, as required by the degree of shock or alkalosis. On reaction from shock, the area is carefully cleansed with a saturated solution of boric acid, and painted with a ½ per cent. aqueous solution of picric acid, previously dissolved in a small quantity of alcohol. Burns become exceedingly sensitive when exposed to the air after an occlusive dressing is used. By treating them under electric light, in dry, warm air, the sensitiveness is rapidly lost, and the granulating ulcer from the burn is no more sensitive than any other ulcer.

During the first and second stages burns should be freely exposed to warm air and should not be covered, except by a thin coating of paraffin oil or wax. *Ambrine* or *burnol* (consisting approximately of paraffin molle 25 per cent., paraffin durum 67 per cent., olive oil 5 per cent., oil of eucalyptus 2 per cent., and beta-naphthol ¼ per cent.) has a melting-point of 48° C. The burn is first washed with saline or boric solution without opening the blisters, and dried by fanning. The melted wax is then applied by a special atomizer or soft sterile camel's-hair brush. This coating prevents crusting, and favors epithelization and the escape of discharges.

A 2½ per cent. solution of *tannic acid*, applied for twelve to twenty-four hours until the parts become light brown in color, is advocated by E. C. Davidson.

Carron oil, composed of equal parts of linseed oil and lime-water (first used in Carron Iron Works, of Sterling, Scotland), *white lead, bismuth paste, carbolized*

oil, and *collodion* retain secretions, promote decomposition and foul odor, render the burn much more sensitive to the air, increase toxemia, complicate dressings, and are, therefore, no longer advised.

In the third stage crusting is prevented or reduced by the application of *compound resin cerate* (containing 10 per cent. of balsam of Peru) on strips of lint. As soon as a healthy granulating surface has been obtained, skin-grafting should be used if the area is large. For certain burns of the fourth, fifth, and sixth degrees, primary débridement under an anesthetic, when the patient has well recovered from shock, is desirable, as it at once converts the burned area into an open, clean wound, which may then be treated by skin-grafting or other measure.

Antitetanic serum is an important prophylactic against tetanus. An ample supply of liquids and nourishing food and free elimination are desirable during the second and third stages. The secondary contractures, especially about the

Fig. 32.—Pedicled flap taken from the opposite thigh to cover an ulcerated area of the heel following an extensive burn of the foot in childhood. An epithelioma which later proved fatal from metastasis to the body had developed in the chronic ulcer from this burn at the age of twenty-six.

face, neck, or joints, should be treated early by Thiersch grafts, and later by the excision or division of the scar, the use of pedicled flaps of skin, or other forms of skin-grafting. Chronic ulceration in the old scar from a burn should never be permitted, as cancerous degeneration so frequently follows.

Burns and scalds of the tongue, pharynx, glottis, and epiglottis may occur from hot liquid, vapors, chemicals, or the inhalation of flame. Marked secondary swelling with pain, dyspnea, dysphagia, and suffocative edema occur. For the swelling, the local application of cold and a 5 to 10 per cent. glycerol of tannin, with ice over the larynx, is used. Scarification, multiple incisions, or tracheotomy may be necessary to prevent death by suffocation.

Chemical burns occur from the caustic acids and alkalies, from phosphorus, arsenic, zinc chlorid, quicklime, and other chemicals. After prompt chemical neutralization the burn should be treated as one produced by heat.

War-gas Poisoning.—Chlorin gas was introduced into warfare by the Germans in the battle of Ypres in April, 1915.

Varieties are: (1) *Lacrimatory* or *tear-gas*, as *xylol bromid*. (2) *Vesicants*, as *mustard gas* or *Yperite*, *dichlorethylsulphid*, and (3) *suffocative*, as *chlorin* or *phosgene* (*diphosgen chloropicrin*).

1. **Lacrimatory** or **tear-gas** (*bromethylmethyl chloroformate*, *monochloromethyl chloroformate*, or *xylol bromid*) produces irritation of the conjunctiva, lacrimation, irritation of the respiratory tract, severe or fatal congestion of the lungs with edema, inflammatory changes in the kidneys, conjunctivitis, keratitis, corneal infection, blistering of skin and eczematous ulceration, and a tendency to septic poisoning of abrasions of the skin.

2. **Mustard gas** (*dichlorethylsulphid*) is an irritant upon the skin or mucous surfaces, causing epigastric distress, emesis followed by a free interval of from four to sixteen hours with conjunctivitis and signs of laryngeal and bronchial irritation, diffuse bronchitis, cough, expectoration, and rapid breathing. Frequently, bronchopneumonia or edema of the lungs follows. Superficial burns are produced on the exposed parts of the skin. The course is turbulent, with high irregular fever, dyspnea, cyanosis, cough and bloody expectoration, ending by lysis or death from pulmonary edema. The blood-pressure is moderately reduced, but the heart and kidneys are only slightly affected.

Upon the skin, even through the clothing, the gas is escharotic. Upon the epidermis, corium, and endothelium of vessels the burns resemble those due to hydrochloric acid. They differ from burns due to heat in the absence of thrombosis, in the greater fluid exudate and moistness of the affected area, and in the slower development of necrosis. The vessels are collapsed, there is local anemia, marked leukocytic migration and fluid exudation which is non-hemorrhagic and non-thrombosing. Necrosis of the epidermis is evident in two hours through the hydropic change in the epithelium and the early vesicle formation. There is no deep edema, and the necrosis is confined to the epidermis and papillary layer in the early stages. The height of necrosis is reached in from five to ten days, the lesion is relatively painless from the edema and degeneration of nerve-endings. Healing is slow from the injury of blood-vessels.

Treatment consists in removal of all clothing and shoes, warm baths, absolute rest, warmth, the free use of fluids, with frequent boric irrigations for the conjunctivitis, phlebotomy, and hypertonic solutions intravenously for the pulmonary edema.

3. **Suffocating gases** (*chlorin*, *phosgene*) are pulmonary and cardiac irritants, acting chiefly on the alveolar epithelium of the lung with rapid onset, edema, thrombosis of pulmonary capillaries, and irritant action on the larynx, pharynx, and bronchi.

Chloropicrin is also a lacrimator like chlorin and phosgene, but not to the same degree, producing an immediate local irritation of the eyes, followed in three to twelve hours by asphyxia, hyperpnea, prostration, edema of the lungs, intense pain in the chest, cough, expectoration, full pulse, distended veins, cyanosis, with blue or plum-colored skin and anoxemia. In the second type there is collapse, with gray, leaden color, and no increase of the carbon-dioxid tension in the blood. Late effects occur after fourteen days with cardiac dis-

tress, spasmodic dyspnea, or combined symptoms. Cardiac effects include precordial pain, marked exhaustion, persistent tachycardia after exercise; nocturnal spasmodic dyspnea at variable intervals, with shallow, rapid, not difficult respiration, slight cyanosis (or normal color) lasting five to thirty minutes, and intense headache and giddiness on exertion.

In milder cases the attacks of dyspnea with dizziness, vertigo, fainting, pain referred to the heart, palpitation, and hot and cold flashes follow exertion. There is tachycardia after exertion, and brachycardia after rest. The blood shows increased coagulability and there is an early and continued fall in blood-pressure.

Chlorin produces edema of the lungs to such a degree that the patient may drown in his own secretions. There is dyspnea, a rapid weak pulse, and lividity, with the white line of Sergent on the skin, suggesting adrenal insufficiency.

Treatment.—In acute cases, *administration of oxygen* if there is anoxemia and cyanosis. Anoxemia is more extreme in the gray cases than in the blue. Continued slight anoxemia for several hours gives the depressing symptoms of *mountain sickness.* If continued, the heart and central nervous system fail. Alkalies and calcium for the acidity are of little value.

Venesection should be used early in cyanosed cases, to reduce threatening dilatation of the right heart. Bleeding is not to be used in the primary gray case or during primary shock. When due to a secondary failing heart from venous engorgement or anoxemia, venesection may be cautiously tried. In all cases free infusion of isotonic salt solution is useful. Prolonged and absolute rest in bed, from the first symptoms of poisoning, is very important.

Cold.—The application of *cold* to a part of the body is followed by temporary hyperemia, succeeded by vasoconstriction and anemia, with tingling, numbness, loss of function, and mottling or pallor. If intense and prolonged, thrombi form in the blood-vessels. When *heat* is applied the frozen part becomes red and swollen, the vessels engorged, serum and cells escape into the tissues with a tingling, throbbing, itching, pricking sensation, and, at times, an arrest of the circulation.

Local necrosis may occur from: (a) Direct effect of the cold upon the tissues, (b) the pressure of inflammatory exudate, and obstruction from vascular thrombosis, a result of rapid thawing. In the first there is dry gangrene; in the second, moist gangrene. Superficial dry gangrene affects the nose, ears, fingers, and toes, usually with the formation of a superficial and painless slough. Moist gangrene from too rapid thawing is marked by swelling, redness, and ulceration.

The *constitutional effects* of cold are, first, stimulation, followed by depression, pain, numbness, and intense drowsiness, succeeded by coma and death from internal congestion. Capillary embolism may follow the rapid thawing of a partially frozen person, with sudden unconsciousness and death, as occurred during the retreat from Moscow when the chilled soldiers of Napoleon hovered about the camp fires.

Pathology.—The local application of cold is followed by hyperemia which, if the temperature of the tissues is markedly reduced, is succeeded by marked contraction of the blood-vessels and anemia, until finally, when the tissues become frozen, they are pale, dry, and bloodless. A part may be frozen for a

brief period of time without especial injury. On thawing, an intense hyperemia succeeds the anemia, and it may lead to rupture of blood-vessels, thromboses and extravasations into the tissue, with secondary necrosis and gangrene. For this reason rapid warming of a frozen part is fraught with great danger, locally and generally. After prolonged freezing the cells fail to regain their function and, upon the restoration of the normal temperature, the blood does not enter the involved area, and local death results. It is, therefore, possible to have a local necrosis directly from the cold itself, or from the secondary hyperemia and exudation following the exposure.

Treatment.—Frozen parts should be very slowly thawed, first by friction with snow, then iced water and cold water, and, finally, dry friction, the application of warmth being delayed to the last. Recovery has followed despite a rectal temperature of 78° F., and after a person has been buried in snow for five days. The secondary redness from superficial frost-bite usually disappears within a few days, but may be permanent, or recur as a local asphyxia when the part is again chilled.

Chilblain or **pernio** results from a previous mild frost-bite, and usually involves the heels, toes, ears, fingers, or nose, the part becoming congested with itching, tingling, and stinging when warmed from exercise or exposure to heat. At times local asphyxia, vesiculation, ulceration or, rarely, sloughing occurs.

The part should be protected from cold or excessive heat, and treated: (1) By rubbing daily with spirit of camphor or camphor liniment; or (2) by painting with equal parts of the tinctures of belladonna, aconite, and iodin, or (3) with equal parts of camphor, menthol, chloral hydrate, and oil of wintergreen.

Radiation Burn.—Sunburn (*Erythema calorica*) develops within twenty-four hours after the action of the light.

Pathology.—Sunlight (solar rays or ultraviolet rays), locally, causes the accumulation of pigment in the skin with freckles and tan; or, if the action is more intense, erythema, desquamation, vesiculation, or even superficial eschars result. The mucous membranes are also susceptible.

Snow-blindness and gold-blindness express the injurious results of strong reflected light upon the retina, while conjunctivitis, blepharitis, and other ocular disorders may be produced. The ultraviolet rays are chiefly responsible for these lesions.

In the tropics serious effects upon the brain and cord occur, and special helmets and spinal pads are worn by Caucasians.

Treatment.—The lesions are usually very superficial, and rapidly improve under protection and soothing non-irritant applications, such as boric acid solution, solution of aluminum acetate, Pusey's cream (menthol, camphor, phenol, bismuth subcarbonate, acacia, olive oil, lime-water), diluted lead-water, black wash, or a simple unguent such as boric acid ointment or lanolin.

Electrical burns usually are due to the resistance of the tissues where the current enters or leaves the body. They vary from superficial scorching to extensive charring. Powerful electric currents also produce muscular spasm during the application of current, followed by relaxation and paralysis. Petechiæ occur in the organs and the blood coagulability is reduced. Fractures of the limbs may occur.

Symptoms.—The burn at first is usually painless. Septic complications or profuse suppuration are unusual. In deep electrical burns there is a dry, firm eschar surrounded by a zone of anemia, with little pain until the third day, when a very painful, slow, moist gangrene occurs, the slough separating very slowly, requiring about three to five times as long as that of an ordinary burn. Erosion of large vessels and secondary hemorrhage are not unusual.

Prognosis.—If not immediately fatal, heavy currents cause pronounced shock, unconsciousness for hours or days, muscular palsies, and anesthesia. Impairment of special senses may remain, but usually there is a gradual return of function. Respiratory palsy continuing up to one-half hour has been followed by recovery under prolonged artificial respiration. Electrical burns tend to slough, resist treatment, and be very chronic.

Prophylaxis.—Rubber shoes and gloves should be worn by linemen. In case of accident the current should be turned off, the wire cut or removed in a manner providing safe insulation. The victim may be pulled from the point of contact by the clothing, or a rope, providing it is dry, but great care must be taken not to touch the body by uninsulated hands.

Treatment.—For the patient, apparently dead, prolonged artificial respiration, tongue traction, intravascular and intracardiac injections of epinephrin, hot enemas, warm blankets, cold douche, a mustard plaster over the heart, or at times venesection or cardiac massage should be tried. Vasomotor stimulants are useful. Alcohol should be avoided.

The local treatment resembles that of a burn from heat. Time will be saved by early débridement and suture where the burn is deep. Iodoform and sublimate should be avoided.

Lightning stroke, representing an enormous static spark, is most frequent in rural districts where there are poor facilities for the dissemination of the force. It frequently strikes a lone tree or other isolated conducting agent. Lightning stroke produces shock, unconsciousness, or sudden death. The local lesions include temporary areas of erythema, suggesting urticaria, discolored hyperemic or scorched areas of skin, often showing an arborescent or dendritic pattern (*lightning figures*); or the skin may be dry and glazed, and resemble an ordinary burn. Fracture or avulsion of limbs occurs as well as associated nerve injury and paralysis.

During thunder storms the shelter of trees, poles, or other tall or isolated conductors should be avoided.

Treatment is for shock. Artificial respiration is used for the respiratory paralysis, and should be continued for an hour or more unless reaction occurs sooner. Surface burns are to be treated the same as burns due to heat.

Roentgen burn (*x-ray burn, focus-tube dermatitis*) is a chronic inflammation of the skin characterized by erythema, pigmentation, hyperplasia, induration, keratosis, alopecia, atrophy, ulceration, necrosis, and a marked tendency to secondary epitheliomatous degeneration. The lesions are most pronounced over the area of entrance, but also occur over the area of exit of the rays from the body, and involve the intervening tissues and organs. The soft tissues become dense, atrophic, and cicatricial; the parenchymatous cells degenerate, especially the lymphoid and less mature types. The bones may de-

velop an osteoplastic periostitis, and cerebral and intra-abdominal disturbances occur. The danger is especially great with prolonged and frequently repeated exposures, especially from low vacuum (soft) tubes and the intense rays of short wave length. Local effects are increased by special idiosyncrasy.

Symptoms.—Burns develop two or more weeks after the application of *x*-rays or radium. There is tingling or itching, followed by erythema, pain, tenderness and epilation, the hairs re-forming unless the deeper layers of the skin are destroyed. Secondary intense neuritis, telangiectasis, irritating scars with keratosis and tendency to ulceration and epitheliomatous formation are common. More marked effects include necrosis of the skin and subcutaneous tissue, and deep, slowly healing, and exceedingly painful ulcers. Healing is retarded by the adjacent fibrosis and vascular and lymphatic occlusion. Extremely painful and persistent is the radium or Roentgen-ray neuritis, which continues six months or longer, and often is seen after the radiation treatment

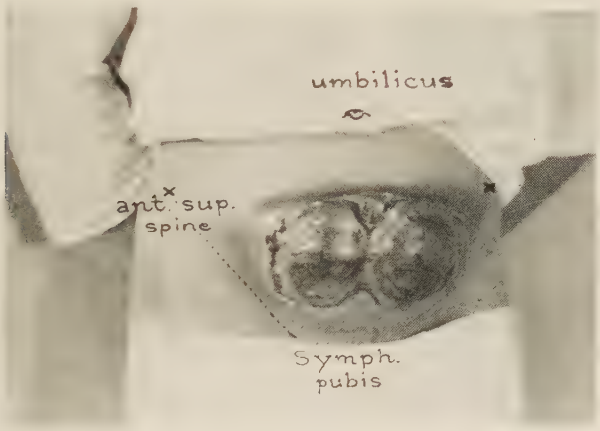


Fig. 33.—Necrosis of the entire thickness of the abdominal wall from the Roentgen treatment of a uterine fibroid. Secondary peritonitis and death. (Dr. C. H. Shearer.)

of malignant disease. Prostration, vomiting, purging, blood destruction, degeneration of the kidneys, liver, and other organs, and death may follow intense radiation. Roentgen operators not infrequently become sterile from the destructive effect of the rays upon the testes. By the modern methods for protection and the accurate measurement of the dosage used, Roentgen burns may be prevented.

Treatment.—For the superficial and milder lesions the treatment is that given for sunburn. Only mild, non-irritating remedies should be applied, as the tissues have little resistance. For deeper lesions, with ulceration and dense fibrosis, excision of the affected tissue and skin-grafting or a plastic operation is desirable, but in the presence of malignancy may be impossible. If there is intense neuritis, healing may be stimulated and pain relieved by the application of the actual cautery (Percy), or sensation may be blocked by the injection of alcohol, quinin and urea, or a 5 per cent. solution of phenol in or near the afferent nerve-trunks of the area.

Radium Burn.—From sufficiently prolonged proximity of radium, induration, pain, erythema, desquamation and chronic ulceration result, and may persist for months.

The local untoward effects of radium resemble those of the Roentgen ray, and the lesions are to be treated in a similar manner.

Historical.—M. Becquerel, in 1906, discovered that certain uranium salts emit radiant energy resembling the Roentgen rays. Madame Curie found that the pitchblendes, chacocite, autunite, cleveite, monazite, and other minerals possess radiant energy. Polonium, radium, and actina were the chief substances found. The rays induce luminosity, have actinic and skiagraphic power, and render the air through which they pass a conductor of electricity. They excite the phosphorescence of gems, and are incapable of polarization, reflection or refraction, and vary in their properties.

CHAPTER V

HEMORRHAGE, HEMOSTASIS, TRANSFUSION

Blood is a liquid tissue consisting of cellular elements, colloids, crystalloids, and water. Each cubic millimeter contains approximately 5,000,000 red blood-corpuscles or erythrocytes, 5000 white blood-corpuscles or leukocytes, and from 225,000 to 400,000 blood-platelets (plastocytes). The blood constitutes from one-tenth to one-thirteenth of the body weight. About one-half of the volume of the blood by weight consists of corpuscles. The total volume of the blood is from 5 to 7 per cent. of that of the body. From hemorrhage the specific gravity of the blood is reduced, with a decrease in red cells, an increase in leukocytes, slight rise in the hydrogen-ion concentration of the plasma, and diminution in the store of reserve alkali with acidosis. After hemorrhage, water is quickly restored to the blood from the tissues, proteins are rapidly replaced from stores held in the liver and elsewhere, the leukocytes soon increase, while the red blood-cells require a number of days for regeneration. The life of the red blood-cell is probably several weeks. Bone-marrow, the liver and spleen, and lymphoid organs (*reticulo-endothelial system*) take part in the formation of the blood, the leukocytes being the primitive red cells, the platelets being derived from the megakaryocytes of the bone-marrow. With the body at rest the adult heart propels about 4 liters of blood per minute, during violent exercise up to 24 liters (Krogh and Haldane). During exertion the blood makes the circuit of the body every ten seconds. Arrest of circulation in the brain is followed by death of the cortical cells in seven minutes; in the extremities death of the muscles occurs in three hours.

Hemorrhage is the escape of all the constituents of the blood from the heart or blood-vessels.

Varieties.—A. According to Source: (1) *Arterial.* (2) *Venous.* (3) *Capillary.*

1. In *arterial hemorrhage* the blood is bright red, projected in spurts, and the flow is centrifugal. The arterial spurts are synchronous with the heart action and the flow more profuse from the proximal than the distal end of the vessel.

2. In *venous hemorrhage* the blood, dark red in color, wells up as a continuous stream, except from the cerebral sinuses, where it may spurt synchronously with the pulse, and from the veins in the neck, where it flows synchronously with the expirations. The flow is centripetal and is increased by gravity, by pressure proximal to the open vessel, cyanosis, straining, forcible exhalation, and holding of the breath. It may be arrested during inhalation, particularly in the veins entering the thorax, and also by pressure distal to the lesion. Venous hemorrhage occurs from the distal end of the divided vein, except where the valves are deficient or incompetent, as in varicose veins.

3. *Capillary hemorrhage* is characterized by continuous ooze of blood under low pressure, the bleeding being increased by cyanosis and rise in the blood-pressure.

B. **As to Method.**—*Hemorrhage* may occur: (1) *By rhexis (per diabrosis)* from a wound or opening of the vessel wall; (2) *by diapedesis*, where the blood filters through the vessel wall without evident opening.

C. **As to Time of Occurrence.**—*Hemorrhage* is divided into: (1) *Primary;* (2) *intermediate* or *reactionary;* and (3) *secondary hemorrhage. Primary hemorrhage* occurs at the time of injury; it is to be treated according to general principles given elsewhere. *Intermediate* or *reactionary hemorrhage* occurs within twenty-four hours of the injury, as reaction follows the shock and lowered blood-pressure attending the operation or injury. It results from increased blood-pressure, general exertion or movement of the part, dislodgment of clot, slipping of a ligature, or failure to secure the distal end of a wounded artery, the collateral circulation being established. The treatment is similar to that of primary hemorrhage.

Secondary hemorrhage occurs later than twenty-four hours after the injury, especially between the seventh and tenth days, usually from secondary infection, necrosis, and ulceration. The ligature may be septic; too quickly absorbed, as with catgut; too narrow and tight, causing ulceration into the vessel, as with bands and ligatures applied to the aorta, or too close to a large branch. The hemorrhage may occur from the establishment of a collateral circulation, or from a branch distal to the ligature. Secondary hemorrhage from large vessels in septic wounds is very serious and frequently fatal. The bleeding at first may be slight or profuse, but it tends to recur. In profuse secondary hemorrhage the bleeding may cease with exsanguination, to recur after twenty-four or forty-eight hours, when the blood-pressure again rises. As secondary hemorrhages tend to recur and be fatal, active measures should always be taken to prevent them. One or more *warning hemorrhages* may occur before the *fatal one.*

D. **As to Extent.**—(1) *Subcutaneous* or *submucous:* (a) *Petechia*, minute reddish or bluish spot from a slight circumscribed effusion. (b) *Ecchymosis*, a black and blue discoloration of moderate extent, characteristic of a bruise. (2) *Deep:* (a) *Extravasation*, *suffusion*, *sugillation*, the effusion involving an extensive area. (b) *Hematoma* is a circumscribed collection of blood in the tissues. (c) *Hemorrhagic infarction*, a circumscribed cone-shaped effusion of blood into the tissues, usually of spleen, kidney, lung or intestine, from embolism of an end artery.

E. **As to Seat.**—(1) Head of the new born child, *cephalhematoma.* (2) Nose, *epistaxis.* (3) Eye, *hemophthalmia.* (4) External ear of the insane or the boxer, *hematoma auris.* (5) Lungs, *hemoptysis.* (6) Stomach, *gastrorrhagia.* (7) Vomited blood, *hematemesis.* (8) Intestines, *enterrhagia* or *melena.* (9) Pleura, *hematothorax.* (10) Pericardium, *hematopericardium* or *hemopericardium.* (11) Peritoneum, *hematoperitoneum.* (12) Urinary tract, *hematuria.* (13) Pelvis of the kidney, *hemonephrosis.* (14) Joints, *hemarthrosis.* (15) Spinal cord, *hematomyelia;* in spinal arachnoid, *hematorachis*, *hemorachis.* (16) Uterus, *hematometria.* (17) Vagina, *hematocolpos.* (18) Fallopian tube, *hematosalpinx.* (19) Excessive menstrual flow, *menorrhagia.* (20) Excessive intermenstrual flow, *metrorrhagia.* (21) Tunica vaginalis testis, *hematocele.*

Pathology.—*Arrest of hemorrhage* may be temporary or permanent. Temporary arrest may be natural or artificial; permanent arrest occurs through tissue repair of the defect that led to the bleeding.

Natural arrest of hemorrhage is produced by: (1) The *action of the vessels* themselves, such as (a) contraction of the divided ends of the vessel, (b) retraction of a vessel within its sheath, or the curling of the inner coats of the vessel within the outer. This is aided by the complete division of the vessels, and especially by blunt or lacerating force. (2) *Thrombosis within the Blood-vessels:* The internal clot extends back to the nearest collateral branch. The central clot is formed in the lips of the vessel and the external clot spreads from between the middle coat and sheath into the adjacent tissues. Clotting of blood is due to the formation of prothrombin in the plasma, which is derived from the disintegration of blood-platelets and leukocytes. This becomes converted into thrombin, which, in turn, acts upon the protein fibrinogen found in the plasma and, aided by soluble calcium salts and thromboplastin derived from the tissues, produces a thread-like meshwork of fibrin which adheres to the vessel wall and other tissues, entangling the corpuscles and forming a clot.

Increased tendency to hemorrhage from: (1) *Diminished amount of fibrinogen*, which occurs in serious disease of the liver, as in phosphorus or chloroform poisoning, acute yellow atrophy, yellow fever, chronic cirrhosis. The clotting time may be normal, but the clot soft and non-adherent. (2) *Deficiency in prothrombin*, which occurs in melena neonatorum, and is relieved by intravenous injections of blood-serum or by blood-transfusion. (3) *Deficiency in thromboplastin*, which is derived from both blood-cells and tissue cells, may occur. (4) *Excess of antithrombin* which may occur in septicemia, pneumonia, miliary tuberculosis and other diseases, or from the action of certain poisons, as hirudin or peptone. (5) *Calcium deficiency*, which occurs in jaundice from combination of calcium of the blood with bilirubin. The condition is improved by intravenous injections of calcium chlorid. (6) *Deficiency in blood-platelets*, from which prothrombin and thromboplastin are derived, occurs in purpura. Hemorrhage is promoted by increased blood-pressure, movement of the part, partial division of the vessel preventing contraction and retraction, sharply incised wounds, and conditions diminishing coagulation, as hemophilia, chronic jaundice, a vegetarian diet, the excessive use of vegetable acids, and certain poisons.

Symptoms of Hemorrhage.—Hemorrhage is followed by pallor of the skin and mucous membranes, air hunger, the respiration becoming quick, gasping, and sighing; the pulse, at first not affected, later becomes progressively more rapid, small, and weak; the skin is cold with a free clammy sweat; the temperature subnormal; there is restlessness, thirst, dimness of vision, syncope, and noises in the ears. The blood shows a leukocytosis of 15,000 to 30,000, and a diminution of red blood-cells and hemoglobin. In secondary and reactionary hemorrhage a temperature of 101° to 102° F. may follow the bleeding. Before death the rectal temperature may reach 104° to 108° F., although the skin is cold and clammy.

Diagnosis is to be made from other conditions in which there are pallor and rapid, weak pulse. In shock there is a concentration of blood, a relative increase of hemoglobin and corpuscles, an absence of leukocytosis; air hunger is less marked, restlessness less common, and the patient is more often unconscious. Cerebral concussion occurs immediately after an injury with uncon-

sciousness and the other signs of shock, and is usually transient. Syncope is of rapid onset and lasts but a short time.

Prognosis.—The effects of hemorrhage are modified by: (1) *Age:* infants and elderly patients bear hemorrhage badly. (2) *Sex:* women are less affected than men. (3) *Constitutional condition:* anemia, asthenia, cachexia, shock, and sepsis render a person more vulnerable to hemorrhage. (4) *Rapid, profuse bleeding* is more dangerous than slow and continued hemorrhage, but a small secondary hemorrhage is more dangerous than a large primary one. A patient may recover from loss of blood up to 3 per cent. of the body weight.

Treatment of Hemorrhage.—Emergency Treatment.—Arrest of hemorrhage may be temporary or permanent: *temporary* by means of a tourniquet, pressure, elevation, compression: *permanent*, as by ligature, torsion, forcipressure, cauterization. The pressure may be *direct* upon the bleeding point, or *indirect* upon the main supplying artery.

Digital Compression.—The *common carotid artery*, the *inferior thyroid* and *vertebral arteries* are compressed against the spinal column or the carotid tubercle (*Chassaignac's tubercle*) or between the thumb and first rib. Pressure on the *carotid* is made by the thumb between the trachea and inner border of the sternomastoid, over the transverse process of the sixth cervical vertebra, the artery being pressed backward and inward against the tubercle; the *external maxillary* against the lower jaw just anterior to the masseter, the *temporal* against the zygoma in front of the ear, the *angular* and *labial* by compressing the cheek at the angle of mouth between the thumb and finger. For the *subclavian artery* the head is turned to the opposite side, and the shoulder depressed and carried forward. The tips of the index- and middle-fingers applied behind the middle part of the clavicle, lateral to the sternomastoid, locate the pulsating subclavian and press it downward, backward, and inward against the first rib. The digital pressure may be replaced by the padded handle of a key, or a pad held by Esmarch's rubber bandage carried for several turns over the shoulder and through the crotch. The *axillary artery* is controlled by a figure-of-8 roller elastic bandage placed over a pad in the axilla. The bandage is carried over the shoulder and under the opposite axilla. The *brachial artery* is compressed against the humerus by the fingers, pressing in the upper third of the arm outward, in the middle third backward and outward, and at the elbow directly backward. Counterpressure is made by the thumb on the opposite side of the arm. The palmar arches are controlled by pressing the radial and ulnar arteries against the bones of the forearm. Hemorrhage (which cannot easily be located) from the *external iliac*, or *hypogastric* is controlled by compression of the abdominal aorta. In *Macewen's method* the surgeon stands on the left side of the patient at the level of the navel, facing the patient's feet, his clenched fist compressing the abdomen slightly to the left of the midline just above the umbilicus, the knuckle of the index-finger just touching its upper border. By leaning the weight of the body upon the fist the aorta is compressed against the spine. Just above Poupart's ligament the *external iliac artery* may be compressed backward against the pubic ramus by the thumb, or by forcible flexion of the hip over a pad. For the femoral artery the operator stands at the outer side of the opposite groin, the femoral artery being compressed just below the midpoint of Poupart's

ligament directly backward against the pubic arch by the thumb, reinforced by the opposite thumb. The *popliteal artery* may be compressed digitally in the midline of the popliteal space, or by acutely flexing the knee over a firm pad placed in the space.

Tourniquets are instruments for the temporary arrest of circulation in a part by external pressure. Tourniquets may damage nerves, muscles, or other structures. The pressure of the tourniquet should be as evenly distributed as possible to avoid contusion and injury to vessels and nerve-trunks, and should be no greater than necessary to arrest the circulation. A tourniquet should be left on for the shortest possible time, never over two hours. It should not be applied over an interosseous space, as over the forearm or leg. A *provisional tourniquet* is one applied loosely, to be tightened on the appearance or recurrence of hemorrhage.

Esmarch's Tourniquet.—A strong, narrow band with a chain attached for fixation. This has largely been supplanted by Esmarch's elastic rubber roller bandage, at the end of which are two tapes for fixation. The bandage, being broader and softer, produces less traumatism than the original tourniquet.

Fig. 34.—Esmarch's tourniquet.

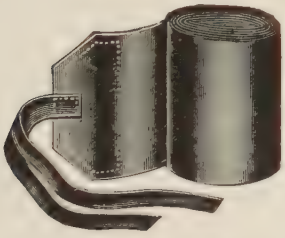


Fig. 35.—Esmarch's elastic rubber bandage.

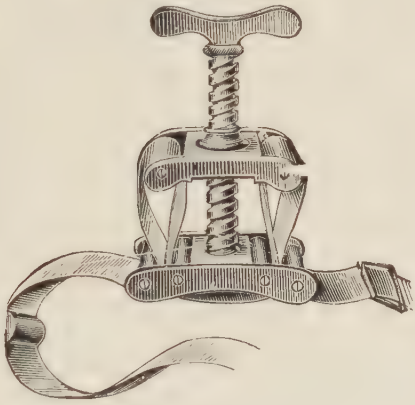


Fig. 36.—Petit's tourniquet.

The amount of constriction used varies with the tension and the number of turns applied. The blood is first emptied from the part by elevation or, if there is no inflammatory, thrombotic, or malignant condition present, by the compression of the rubber roller bandage, firmly applied from the tips of the fingers or toes upward. When the height for the application of the tourniquet is reached, the bandage is wound smoothly and tightly about the limb (best over two or three turns of a flannel roller bandage) and the elastic bandage below removed.

Spanish windlass (*torcular* or *garrote tourniquet*) is the simplest improvised tourniquet and is made out of a knotted handkerchief or heavy cord, loosely tied about the limb and tightened by passing a stick through the loop and twisting. The *field tourniquet* is merely a padded strap and buckle.

Petit's tourniquet, a time-honored device, consists of two plates separable by

a screw, to which a strong webbing strap is attached. The lower plate is applied upon a pad directly over the main artery, the strap snugly buckled about the limb, and constriction of the limb and compression of the main artery against the bone caused by screwing the plates apart.

Samway's tourniquet is formed of strong rubber tubing with an anchor-shaped fastening, under which the free end of the tube is caught. Rubber tubing should not be used on the arm, as it may injure the nerves.

Signorini's tourniquet (*horseshoe tourniquet*) consists of two hinged metal arms with pads at the extremities, which are approximated by a screw and pinion.

Momburg's Tourniquet or Belt.—A rubber tube (as thick as the thumb or finger, and stretched to the utmost) is wound around the trunk two to four times, midway between the costal arch and the iliac crests, until all pulsations are arrested in the femoral artery at the ligamentum inguinale. It should only be applied under general anesthesia, the bowel and bladder first being emptied. *The pressure may be continued for forty-five minutes.* Damage to viscera from its use has been reported.

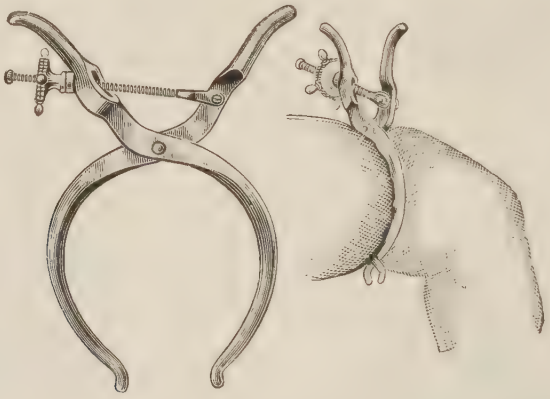


Fig. 37.—Truesdale's all-metal tourniquet for instant application.

Pneumatic tourniquet is a narrow rubber bag arranged to be bound around the limb, pressure in which is raised by pumping in air by a hand-pump. *Foulis's tourniquet* consists of a strong rubber cord or tube, with a doubly grooved wooden or vulcanite block which catches and holds the ends of the cord.

Truesdale's screw tourniquet has hinged rigid metal arms which encircle the limb and are approximated by a screw, producing the required pressure.

Lynn-Thomas tourniquet forceps are elastic metal compression-forceps, to be passed through wounds for the massive compression of tissues and the arrest of hemorrhage, especially during amputation.

Provisional or *temporary hemostasis* of exposed arteries is obtained by the use of Doyen's soft arterial clamp, Crile's arterial clamp, a tape, or provisional ligature.

Special Methods Used in Arrest of Hemorrhage.—1. **Cold and Heat:** Ice and iced water stimulate the contraction of blood-vessels and the arrest of hemorrhage, especially from capillaries and small blood-vessels. For internal hemorrhage an ice-bag applied over the bleeding part is useful. For gastric or

duodenal hemorrhage, lavage with water at 120° F. is used. Warm and lukewarm applications favor hemorrhage. Heat up to the point of coagulation or charring has been used from the time of the ancients, who employed heated knives, while in the middle ages boiling oil was poured into bleeding wounds.

2. **Elevation and Position.**—The bleeding part should be kept elevated and in a position to prevent venous obstruction. Venous hemorrhage may often be arrested by merely raising the part well above the general level of the body.

3. **Pressure is Applied:** (a) *Directly* in the wound, as by a graduated or conical compress, by gauze packing, filling the cavity with plaster of Paris or other plomb, by pressure of the fingers or a hemostat, or a bandage directly over the wound. (b) *Indirectly* by a tourniquet, the sharp flexion of a proximal joint over a pad or bandage, the compression of the main artery by the finger or a padded key or other device. Special pressure-forceps are used after tonsillectomy.

Agents Acting Locally.—1. **Chemical Coagulants and Astringents:** *Styptics* produce large masses of tough adherent clot, under which bleeding may continue. The styptics include tannic acid, alum, persulphate of iron (Monsell's solution), turpentine, tincture of chlorid of iron, copper sulphate, and chromic acid.

2. **Organic coagulants,** supplying cephalin or thromboplastin, are often very effective in arresting hemorrhage with the formation of but little clot. Cephalin (kephalin, brain lipoid made from brain substance) or thromboplastin are usually preferable to the styptics. It may be applied locally, the solution or powder being pressed against the bleeding surface, or injected subcutaneously or intravenously, remembering that a negative phase may follow the injection. Hemorrhage may be arrested by applying a bit of muscle to the bleeding point, as in the arrest of hemorrhage from the brain or pia mater.

3. **Vasoconstrictors,** such as cocain, or epinephrin and ephedrin, produce a marked local constriction, local pallor and reduction in hemorrhage which, however, may be followed by secondary vasoparesis and an increased tendency to bleed.

To be effective, adherent blood-clots should be removed before the styptic or coagulant is used. The drug is best applied on gauze or cotton with compression. Where the vessels are no longer contractile (as in a bleeding ulcerated sarcoma) a compress or packing of gauze wet with turpentine is very effective, although the turpentine may blister adjacent skin with which it remains in contact.

4. **Cauterization.**—The most effective is the thermocautery at a black or dull-red heat. The cautery at a red or white heat cuts the tissues somewhat like a knife, causing insufficient searing to properly prevent hemorrhage. The *radium knife, endotherm knife,* a needle or wire actuated by a high-frequency current, rapidly divides tissues, closes the smaller blood-vessels and capillaries, but does not arrest hemorrhage from the larger arteries or veins.

5. **Torsion or Twisting.**—In this the vessel is caught and twisted until the inner and middle coats give way and curl upon themselves. Torsion is continued until the coats are felt to partially give way, or until the end has been twisted off. *True torsion* is applied with a single pair of forceps. In *limited*

torsion the vessel is grasped with one forceps while being twisted with another. Torsion is only used for arteries of moderate size.

6. **Forcipressure.**—Arterial forceps (hemostats), applied to crush the vessel and left in place for a few moments, will arrest the bleeding from vessels of moderate size. By the *angiotribe* enormous pressures are produced, capable of closing vessels of large size.

7. **Ligation.**—Arterial ligature (practised by the ancients, and reintroduced into surgery by Ambroise Paré in the sixteenth century) forms the most reliable method of occluding vessels. Ligatures usually are applied with sufficient force to rupture the intima and media, but a simple approximation of the intima is all that is required. Rupture or division of the wall increases the danger of secondary hemorrhage. The ligature may be of silk, linen, catgut, animal tendon, rubber, or metal. Silk and linen are secure and unyielding, but, in the presence of infection, form persistent sinuses or local abscesses, and require removal. In the pre-antiseptic days the ends of the ligature were left out of the wound, the ligature being withdrawn after the artery, occluded by thrombosis, had been divided through pressure necrosis. A ligature should be tied with a square, reef, or surgeon's knot. Ligatures of plain catgut are now largely employed and should always be used in septic fields. For larger vessels double ligation should be utilized. Catgut should be tied with three square hitches, as the knots tend to swell, become slippery, and untie. Minute *silver clips*, formed by cutting and bending strands of fine flat silver wire, and applied by special forceps, are useful for occluding the delicate vessels of the meninges and brain. Silver is well tolerated by the tissues, even in the presence of infection.

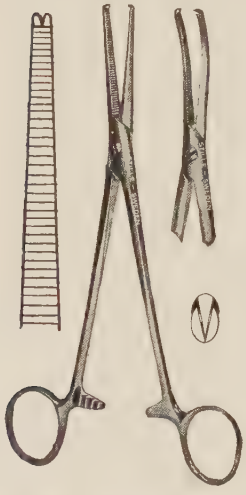


Fig. 38.—Kocher's hemostatic forceps.

After ligation, the clot (*thrombus*) forms in the vessel from the ligature back to the first collateral branch and becomes organized. If the ligature is of catgut, it is absorbed; if of silk or linen, it may cut its way into the vessel and become encysted. Ligation is successful for all arteries up to the abdominal aorta. The abdominal aorta has only once been successfully ligated, the ligature tending to cut gradually through into the lumen of the vessel, with death from secondary hemorrhage.

Varieties of Ligature.—1. Total or *circumferential ligature* is one surrounding the vessel. It may be: (a) a *terminal ligature* at the divided end of the vessel, or (b) a *ligature in continuity* applied at a distance from the arterial injury or disease.

2. *Lateral ligature* is non-occluding, and closes an opening in the lateral wall of the vessel.

3. *Individual ligature* is that applied to a single vessel only.

4. *Mass ligature*, one in which a quantity of tissue is constricted, together with the vessel.

5. *Suture ligature*, a form of mass ligature passed by a needle through the

tissues and about the artery, hemorrhage being prevented by the compression or approximation of surrounding tissue.

6. *Interlacing, interlocking,* or *chain ligature* is used for securing a broad pedicle, and consists of a series of interlocking loops. It is employed for the omentum, mesentery, liver, kidney, and for large sacs.

7. *Erichsen's ligature* (used for angioma) is an interlocking ligature; for convenience of identification, one black and one white thread being used.

8. *Intermittent ligature,* or tourniquet, is used to delay the absorption of poison from the tissues, as after snake bite.

9. *Occluding ligature* produces complete arrest of circulation.

10. *Subocculding ligature* incompletely arrests the vascular flow through the vessel.

11. *Provisional ligature* is one temporarily applied, as during an operation, and later removed.

12. *Double ligature* consists of two adjacent ligatures applied to the same vessel, between or beyond which the vessel may be divided.

Fig. 39.—Dry gangrene, late stage, from gunshot wound of the pelvis. Lines of demarcation and separation shown. (Case of Private Strauss, Surg. Hist., War of Rebellion.)

13. *Elastic ligature* is formed of a stretched rubber cord which gradually cuts its way through the tissues. It has been used for the bloodless division of deep rectal fistula, the removal of pedunculated growths, in *McGraw's method of gastro-enterostomy,* and in the treatment of hemorrhoids.

Collateral Circulation.—After ligation of an important artery the blood is diverted about the constriction by anastomosing collateral channels. The collateral circulation may be established immediately, after some hours, or after days, with the dilatation and enlargement of the collateral arteries. It may be efficient even after ligation of the abdominal aorta. Ligation of the main artery of a limb is followed by some reduction in circumference, decrease in power, some muscular atrophy, and a fall in the distal blood-pressure. After ligation of the popliteal, femoral, or axillary arteries the collateral circulation is not always sufficient and gangrene of the extremity may follow. After ligation of the

common carotid, hemiplegia from cerebral degeneration occurs in 26 per cent. of the patients.

Rules for the Ligation of Wounded Arteries.—(1) In primary hemorrhage with the bleeding arrested, ligation should not be attempted unless the artery is exposed or readily accessible in the wound. (2) In active primary or secondary hemorrhage the vessel should, if possible, be secured in the wound at the point where it is bleeding. (3) Both ends of the divided artery should be tied. If the vessel is partially divided and arteriorrhaphy impracticable, division should be completed and both ends of the artery ligated. (4) Ligation in the continuity of arteries has a very limited application.

Prophylactic ligation (*preliminary* or *precautionary ligation*) is used where necrosis and sloughing involving large vessels are to be expected. For example, in cautery destruction, electric coagulation, or excision of the tongue for malignant disease, precautionary ligation of the lingual arteries is often desirable. With similar procedures on the face or jaws, ligation of the external carotid is used. After the use of radium, and in certain very destructive wounds that evidently will be followed by extensive sloughing, precautionary ligation may be desirable. Where secondary hemorrhage from an extremity is feared, the part should be kept elevated, with a tourniquet loosely in place so that it may be instantly tightened. In other cases sterile instruments and supplies for instantly clamping, ligating, or packing the wound for hemorrhage should be kept by the patient's bedside. *If the surgeon delays with the first warning hemorrhage, he has no excuse for delaying with the second*, and active measures should immediately be taken to prevent the death of the patient.

Methods used for secondary hemorrhage include: (1) *Arrest of hemorrhage within the wound* by ligature, suture, clamp, or packing, which is preferred when it is feasible. In hemorrhages after vaginal hysterectomy, ligation or whip stitching followed by antiseptic packing should be used. An infected wound, unless there is grave danger of disseminating the infection, should be freely opened, cleared of clot and of necrotic material, the vessel ligated proximally and distally, and Carrel-Dakin treatment instituted; or the sloughing surface is destroyed and coagulated by the actual cautery at a dull red heat. In an emergency the wound may be opened, the bleeding point crushed with clamps which are left on, and the wound firmly packed with iodoform or other antiseptic gauze. In a sloughing wound there is danger of recurrence of the hemorrhage after this treatment; and, with continued marked infection or severe sloughing, (2) ligation of the main artery in continuity through a clean field at a distance from the wound should be considered. (3) *Removal of the Part:* Where ligation of the main artery of a limb has failed, amputation may be required to save the life of the patient. Secondary hemorrhage from a vascular organ (as the spleen or kidney), which cannot be controlled satisfactorily by packing, cautery, or ligature, necessitates the removal of the organ.

Acupressure (Sir James Y. Simpson, 1859).—This is an old and simple method of controlling arterial hemorrhage, now only to be considered in an emergency where better methods are not available. A large needle, a darning needle, or hat pin may be used. In the *first method* the needle is passed through the skin, under the blood-vessel, and out through the skin again, raising and

compressing the vessel against the overlying skin. The effect may be increased by twisting a wire or thread around the ends of the needle, as with a harelip pin. In the *second method* the needle transfixes the tissues in such a way as to compress the skin and subcutaneous parts upon the blood-vessel, as a flower stem is pinned to the coat. In the *third method* the pin is passed close to or through the blood-vessel, rotated sufficiently to twist the vessel and occlude the lumen, and the torsion maintained by then thrusting the needle deep into the tissue beyond.

Acupressure may save life, as in obstinate hemorrhage of the umbilical stump in the newborn, the base of which may be transfixed by one or two pins under which a tape or ligature is snugly wound.

General Treatment of Hemorrhage.—(1) The bleeding part should be elevated as far as possible above the level of the rest of the body. (2) The patient should avoid exertion, and remain quietly in bed. (3) An ice-cap should be applied over the bleeding part. (4) Fainting should be encouraged, stimulants avoided. Bleeding often will instantly stop as soon as the patient faints. (5) The coagulability of the blood should be increased by the intravenous injection of 5 c.c. of a 10 per cent. solution of calcium chlorid, particularly in jaundice or other conditions associated with calcium deficiency. Small transfusions will supply necessary platelets in purpura, furnish thromboplastin in hemophilia, and, as a rule, shorten the clotting time. (6) Atropin, gr. $\frac{1}{30}$ to $\frac{1}{100}$, by hypodermic injection is often effective for internal, and especially uterine hemorrhage. (7) The subcutaneous injection of gelatin (danger of tetanus) or ergot, and the administration of human or horse serum, parathyroid, ovarian, or thyroid extract are occasionally of value. Certain types of menorrhagia and nephrorrhagia disappear with a change in climate.

Arterial hemorrhage from a divided vessel should be controlled by proximal and distal ligation. In a septic wound catgut is preferable to linen or silk. Lateral wounds of large and important blood-vessels should be closed by arterial suture, using a very fine silk or linen and a No. 10 to 12 straight bead-threading needle.

A divided femoral or other large artery, important for the vitality of the limb, should, if possible, be united by end-to-end arterial suture. In an emergency, arterial hemorrhage may temporarily be controlled by —(a) *tourniquet*, which should not be left on a limb, without being loosened, for more than two hours for fear of gangrene; (b) *packing* or *pressure*, or (c) the *application of clamps* which are left on the vessels for forty-eight hours, or applied with great force (as with the angiotribe) for two or three minutes and then removed. (d) Acupressure may be valuable in an emergency.

Treatment.—For: (1) *Primary* or *immediate hemorrhage*, the surgeon should ligate or suture at the seat of the injury. (2) *Recurrent* or *reactionary hemorrhage*, occurring within the first twenty-four hours after surgery, should be treated like primary hemorrhage. (3) *Secondary hemorrhage*, which occurs usually from the seventh to the fourteenth day from secondary necrosis and suppuration, and which may be preceded by prodromal symptoms, such as rise in temperature, increase in pulse rate, one or more slight bleedings, local pain, and increase in blood-pressure, should be treated (a) by ligation within the wound, (b) by opening and careful packing of the entire wound, or (c) by a proximal ligation

of the main artery, or (d) amputation may be necessary. For slight hemorrhage, fluids should be given by mouth or intestines, and salt solution injected under the skin. For moderate hemorrhages, fluids should be freely used. For severe hemorrhages, blood-transfusion is indicated, but intravenous infusion of saline is valueless and may even do harm by diluting the reduced quantity of blood. Transfusion is to be used if the hemoglobin is 30 per cent. or below, or if the systolic blood-pressure remains below 80 for an hour or more.

In arterial injury (to prevent the sudden interruption of the circulation with gangrene) temporary conduits, as Tuffier's silver tubes coated with a mixture of paraffin and vaselin, having a melting-point of about 118° F., may be inserted in the artery. The tube becomes occluded by clots after some hours or days, and should be removed by the fourth day or before, and a ligature applied. The tube may maintain the circulation pending the development of a collateral circulation.

Arterial hematoma should be opened and the bleeding vessels secured only when rapidly increasing in size, when there is constant oozing, harmful pressure upon adjacent structures, obliteration of the distal pulse, or infection.

Venous hemorrhage is best controlled by ligature or suture. When the intravenous pressure is low, as in the neck, the pressure of adjacent fascial or muscular surfaces with elevation of the upper part of the body suffices. Pressure, packing, or graduated compresses are sometimes required. With a free oozing from sloughing tumors (particularly sarcoma) pressure and packing may fail, the blood flowing through the meshes of the gauze. Gauze, when wrung out of turpentine, however, becomes impervious to blood, rendering the pack or compress effective. If applied to the unbroken skin, the turpentine will cause a blister.

Capillary hemorrhage is usually controlled by suture, or pressure and elevation.

Internal Hemorrhage.—(1) *Complete rest*, local and general. (2) *Elevate* bleeding part (Fowler's position). (3) *Increase blood coagulability*—300 c.c. of 2 per cent. calcium chlorid intravenously, 10 to 20 c.c. thromboplastin subcutaneously, 20 to 100 c.c. of typed human blood intravenously, or 20 c.c. of horse-serum subcutaneously (urticaria, anaphylaxis). (4) *Ice-bag* over affected part. (5) *Hemostatics:* If intra-abdominal, very tight bandage to increase intra-abdominal pressure. Tannic acid, 0.6 to 2.6 gm.; turpentine, 2 c.c., in emulsion; Monsell's solution or adrenalin, 0.6 c.c.—if the part can be directly reached by drug. Ergot, 8 c.c.; gallic acid, 1.3 gm.; turpentine, 2 c.c.—if part is to be reached through the blood-stream. (6) To maintain a low blood-pressure, three extremities may be corded close to body tightly enough to prevent the venous return, the cords being shifted every two hours to prevent death of tissue. In this way a part of the blood is segregated in the limbs. (7) Avoid stimulants. (8) Favor syncope.

Special Hemorrhages.—1. *Tooth Socket:* Cephalin on a cotton packing, Wright's hemostatic (consists of formalin, 2 c.c., in gelatin, 40 c.c.), with which the cavity is filled.

2. *Tongue:* Pull the tongue or stump of tongue forward. If no other instrument is available, pass the index-finger down to the epiglottis and pull

the base of the tongue forward. A suture or ligature is usually desirable, or the ligation of the lingual artery may be necessary.

3. *Hemorrhage after tonsillectomy* is treated by: (a) Applying a cephalin tampon between the pillars; (b) locating and ligating the bleeding vessel; (c) suturing the pillars together or the tissues about the vessel; (d) the application of a tonsil compressor or hemostat.

4. *Epistaxis* (hemorrhage from the nose) is usually from a small ulcer on the septum a short distance from the *anterior nares*. It is controlled (a) by applying cocain-adrenalin, removing the clot, and cauterizing the bleeding point with a hot probe, or chromic acid fused on a probe; (b) by applying cephalin on gauze or cotton, or (c) by packing the nares with gauze. For the *posterior nares*, the posterior pharynx is plugged by a tampon pulled in place by a string carried from the mouth through the nose by a soft-rubber catheter or Bellocq cannula. The anterior nares is then packed with gauze. It is wise to impregnate all gauze used in the nose with subnitrate-of-bismuth powder, to reduce the danger of infection of the middle ear. A large soft-rubber finger-cot or similar device may be introduced into the nares, and inflated so as to produce pressure. An emergency domestic expedient for nasal hemorrhage is to introduce into the nostril a cylinder of salt pork, shaped like the little finger.

5. *Cranial Hemorrhage.* In operating upon the brain, bleeding from the diploë is arrested by crushing the bone, pressing in a bit of muscle, or applying Horsley's carbolized wax (a catgut or wooden plug may be introduced into bleeding foramina). Bleeding from the dura or pia-arachnoid is controlled by fine ligature or minute silver-wire clips applied with forceps. Oozing from the pia-arachnoid and brain is arrested by applying a bit cut from an adjacent muscle.

6. *Rectal Hemorrhage.*—The injection of iced water, Hamamelis or cephalin solution, or ice suppositories may be tried. A *petticoated catheter* is made of a 14- to 16-inch French rubber catheter, passed through the center of a square of gauze or lint to which it is firmly tied. This is introduced into the rectum, and sufficient gauze introduced between the fabric and the catheter to produce pressure and arrest the bleeding.

7. *Vesical Hemorrhage.* Irrigation of iced water or water at 110° to 120° F., with astringent (as a 1 per cent. solution of alum or a 5 per cent. solution of extract of Hamamelis in water), is useful. After prostatectomy a dilating bag (Hagner) or gauze packing is desirable.

8. *Gastric Hemorrhage.*—Lavage with iced water or very hot water (120° F.) through a duodenal tube is, at times, useful. The withholding of all food by mouth is desirable. Rarely, operative exposure for bleeding, with cauterization, excision, or ligation, is necessary. In operations on the stomach great care should be taken, by accurate suturing and ligation, to prevent secondary hemorrhage from the lines of suture.

Hemophilia (*bleeder's disease*) is characterized by an hereditary tendency to hemorrhage with prolonged clotting-time of the blood, occurring in males, but transmitted only by females. In hemophilia the fibrinogen and platelets are normal, the calcium is not deficient, and the prothrombin may be normal. There is, however, a possible deficiency of thrombokinase, or a defect in the tissue cells and not in the blood.

Symptoms.—The hemorrhagic tendency appears in infancy, rarely at birth with bleeding from the navel, and tends to diminish with age. A fatal hemorrhage may follow a slight injury, such as the extraction of a tooth, a cut, or circumcision. Large, spreading subcutaneous hematomas result from slight trauma. Hemorrhage into the joints, especially the knee, is common, the blood being absorbed with functional restoration or being organized with ankylosis. Hemorrhage in the spinal cord may cause a transverse myelitis. Secondary anemia results from the hemorrhage.

Diagnosis.—An hereditary disease of males, transmitted only by females, with a tendency to repeated or prolonged hemorrhages on slight provocation, commencing in infancy and associated with delayed coagulation of the blood.

Prognosis.—The condition is more dangerous in childhood, improving with age, the intensity varying in different families.

Mucous hemorrhages are common, including epistaxis, hematemesis, and melena. In severe forms the patient rarely survives. Sixty per cent. die before reaching the age of eight, but after puberty the tendency to hemorrhage is lessened. Only 11 per cent. live to the age of twenty-two.

Treatment includes prophylaxis against injury and avoidance of operation, if there is a hemophilic tendency. Locally, pressure and rest are to be used. Sutures and cautery should be avoided, as hemorrhage occurs from the suture holes and cauterized surfaces. Blood-clot should be removed and brain extract, cephalin, adrenalin, extract of thymus, or turpentine applied with pressure. Intravenous injections of 10 to 20 c.c. of human or horse-serum, or direct transfusion of 500 to 750 c.c. of typed blood may be useful.

Blood-transfusion.—**Historical.**—About 1660, Lohr, at Oxford University, transfused blood from one dog to another by means of a goose quill. Two years later, Sir Christopher Wren and Archibald transfused a debauched man with 12 ounces of sheep's blood, without fatality. Defibrinated blood, introduced in 1835 by Bishop, proved dangerous, but in 1898 direct transfusion was popularized by Crile. The convenient citrate method devised by D'Agote, of Montpellier, has, on account of frequent secondary reactions, been largely supplanted by the transfusion of typed, unmodified blood.

Indications.—(1) To *replace blood-loss* and to *shorten clotting-time*, as in severe hemorrhage from ruptured tubal pregnancy, gastric or duodenal ulcer, typhoid ulcer, hemorrhage in pregnancy, purpura, hemophilia, and pernicious anemia. (2) In *staphylococcic*, *streptococcic*, and *other infections*. (3) In *acute gas-poisoning*. (4) In *purpura*, small transfusions should be used. (5) In *hemophilia*, 20 to 100 c.c. should be given every month, and (6) in *pernicious anemia*, 200 c.c. every week preceding splenectomy. (7) In *infection*, three full doses of the appropriate vaccine may first be given, at five daily intervals, to the donor. Five days after the last dose, the blood is transfused. (8) In *poisoning*, exsanguination transfusion, or transfusion preceded by phlebotomy, is at times used.

If, for shock or hemorrhage from injury, appropriate treatment (including rest, heat, and the use of fluids) fails to raise the systolic pressure to 90 mm. of Hg in one hour, transfusion should be used.

Transfusion is of little value and is dangerous in acute sepsis. In chronic

sepsis it is chiefly of value in temporarily reducing the anemia. Is useless in burns, except in the chronic stages to relieve the anemia. It is without permanent value in pernicious anemia, and carries a hazard. It is of chief use in acute shock or anemia from hemorrhage immediately preceding or following an operative procedure. It has little value in forms of shock not due to hemorrhage. The mortality of transfusion is 2 per cent. or less. After death from transfusion petechiæ are found in the pleura, epicardium, bladder, and necrotic foci in the liver and kidneys. Hemolysis from the injected serum, a toxic action, especially upon the liver, anaphylactic shock, and the transmission of disease are the chief dangers of transfusion.

Citrate Method.—Ten c.c. of a 3 per cent. solution of citrate is used for each 100 c.c. of blood. A small quantity of the solution is placed in an Ehrlenmeyer flask, into which the blood flows, and the citrate solution is added gradually, with gentle agitation as the blood is collected. Chemically pure sodium citrate, freshly distilled water, and very slow transfusion are important. A No. 16 needle is preferred. If an incision is required, the saphenous vein may be used to avoid a visible scar. Blood may be introduced into the superior longitudinal sinus or into the peritoneal cavity in children.

Transfusion of whole blood from a suitably typed and tested donor is preferred as causing fewer reactions than the administration of citrated blood.

By typing, human blood falls into four groups: Group 1, forming 5 per cent.; Group 2, 40 per cent.; Group 3, 10 per cent., and Group 4, 45 per cent. of individuals. Group 4 is the universal donor; Group 1, the universal recipient. It is best to select a donor of the same group. If a reaction occurs, ♏10 of adrenalin should immediately be given hypodermatically.

Starting with a known Group 2 and Group 3 sera, a drop of Group 2 serum and one of Group 3 serum are placed upon opposite ends of a clean glass-slide. With each of these drops a drop of blood from the person tested is carefully mixed. Brick-dust precipitation indicates agglutination. Where this occurs with both sera, the individual belongs to Group 1; if in Group 3 serum only, to Group 2; if in Group 2 serum only, to Group 3, and if there is no agglutination, to Group 4.

Blood-reactions from transfusions may be due to subtypes of the four main groups of blood. As a rule, blood of the Group 4 or universal-donor type should not be used for transfusion in any other group. Repeated transfusions from the same donor produce reactions probably from the development of specific agglutinins. If sodium citrate is used, it should be chemically pure. It should not be repeatedly boiled and the water used should be freshly distilled. Reactions also occur from the use of new rubber tubing, which gives off soluble toxic substances (Galland).

Emergency.—Agglutinin test (Lee's) may be used when standard type 2 and type 3 sera are not available. One c.c. of blood from the patient is permitted to clot, and 1 drop of the serum removed and mixed with a drop of a 1 to 10 suspension of the blood from the donor in 1.5 per cent. citrate solution on a glass-slide. On standing, agglutination is shown macroscopically in a few minutes by a precipitate of fine coffee-grounds appearance. If the precipitate does not appear, the blood may be used.

Obviously, the donor should be free from syphilis or other communicable disease.

Methods of Transfusion.—Direct Method.—Usually the radial artery of the donor is selected, and directly united by suture or special device to the basilic vein of the recipient. Occasionally a short paraffin-coated cannula of glass or metal has been used to join the two vessels. Direct transfusion has been discarded owing to the difficulty in technic, damage to the artery of donor, incisions required, the tendency of clotting to obstruct the flow, and the difficulty in estimating the amount of blood transfused.

Kimpton-Brown Method.—A large paraffin-coated glass cylinder (Kimpton-Brown tube), with the lower end drawn out to a point for introduction into the vein, is used. The cylinder is filled with blood from the vein of the donor by suction upon a tube running to the upper part of the cylinder. After the cylinder is sufficiently filled, the tip is inserted in the vein of the recipient, and the blood expelled by forcing air into the cylinder. As the blood is frequently lost through coagulation, the method has largely been supplanted by the syringe or an apparatus injection method.

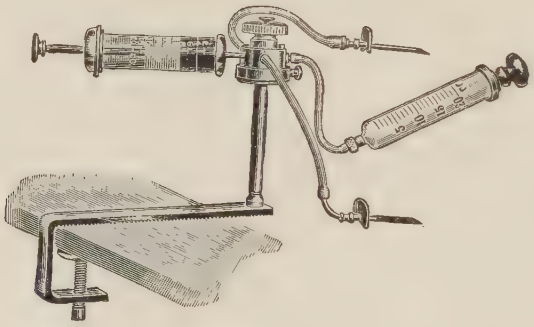


Fig. 40.—The Unger apparatus for transfusion. The Luer syringe is used to supply saline solution to prevent clotting.

Syringe method of transfusion (Linderman) is simple and reliable. Two operators, an assisting nurse, three or four Luer glass syringes of 10 c.c. capacity, two 16-gage needles, and a basin of warm sterile saline or 2 per cent. citrate solution are required. One needle, pointing to the periphery, is introduced in the vein of the donor, distal to a light tourniquet that does not compress the arteries but impedes the venous return. The second needle is introduced in a vein of the recipient and points toward the body. The needles are always introduced in the donor without incision. The recipient may have such small or collapsed veins that an incision is necessary. The interior of the glass syringes are lightly coated with paraffin oil, to reduce coagulation and adhesion of the pistons. Operator No. 1 fills a syringe with blood from the donor, and passes it to Operator No. 2, who injects the blood through the needle into the vein of the recipient and immediately passes the empty syringe to the nurse. The nurse instantly disassembles the used syringe, washes it free of blood, assembles it, leaving a small quantity of the solution in the syringe, and passes this or an extra empty syringe to Operator No. 1 the instant he has filled a syringe. With good team work the

removal of blood, the injections, and the preparation of syringes are almost continuous.

Apparatus methods are more direct than the syringe method and require but one or, at the most, two operators. A Record or Luer syringe is connected by tubing and needles with the veins of the donor and recipient, with interposed valves or cocks so arranged that the blood may properly be drawn and injected. To prevent obstruction through clot formation the interior of the apparatus is coated with paraffin oil, the syringes and valves are chilled by dropping ether upon them, and a by-pass is provided so that saline or other solution may be drawn through the apparatus while it is in use. Of the many devices, that of Unger and Scannell are illustrated.

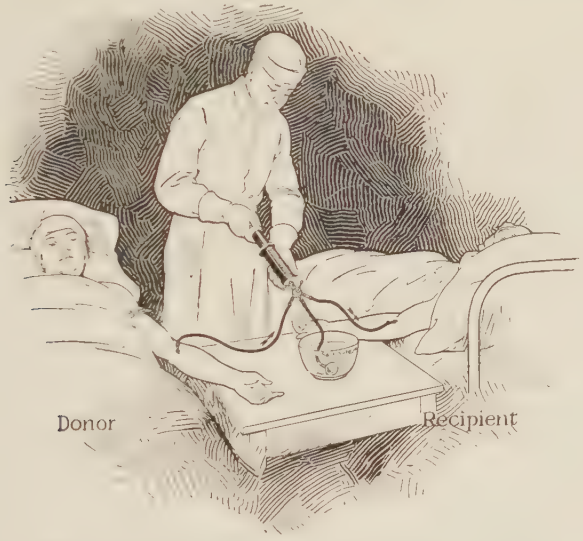


Fig. 41.—The Scannell apparatus for transfusion with three-way valve.

Blood Substitutes (should be buffered with phosphates).—*Bayliss Gum-acacia Solution:* Sixty grams of colorless lumps of best acacia are powdered, suspended in 300 c.c. of normal saline, and stirred; after standing in the refrigerator over night, normal saline is added to make 1000 c.c. The solution is placed in a boiling water-bath for thirty minutes, the volume restored with distilled water, and the solution titrated and neutralized with sodium carbonate; then autoclaved fifteen minutes at 15 pounds pressure, and filtered under pressure through cotton and two sets of alternating layers of linen and hard filter-paper. The preparation is then distributed in 300 c.c. flasks, autoclaved for fifteen minutes at 15 pounds pressure, and stored in the refrigerator for use. Alarming reactions and death have been reported from the use of gum solutions by intravenous injection, especially after the rapid introduction of the solution.

CHAPTER VI

THROMBOSIS AND EMBOLISM

THROMBOSIS

Thrombosis is a coagulation of blood occurring in the heart or blood-vessels during life. The thrombus formed should be differentiated from clot produced by the coagulation of the blood outside the blood-vessels.

Etiology.—Thrombosis results from: (1) *Changes in the blood*, as from *poisons*, which may be (a) *bacterial*, as in pneumonia and diphtheria; (b) *animal*, as foreign serums, thymus extract, and (c) *chemical*, as alcohol, ether, or chloroform. (2) *Changes in the vessels*, as from trauma, inflammation, atheroma, or aneurysm. (3) *Changes in the rate of flow*, as after vascular obstruction and in the agonic period.

The *chief clinical causes* are: (1) *traumatism* involving the vessels; (2) *arteriosclerosis;* (3) *valvular heart disease* and *embolism*, and (4) it is not uncommon in certain *general* or *local infections*, such as typhoid fever. Venous, arterial, or cardiac thrombi occur. Thrombi are found chiefly on the left side and in the lower extremity. The great saphenous vein, the femoral, popliteal, iliac, axillary, pulmonary artery, and the aorta are especially affected. Terminal thrombi may form in the toes, ear, nose, face, neck, perineum, or the male and female genitalia, causing necrosis or gangrene.

Height of Gangrene Following Thrombosis or Embolism.—*Tests.*—Absence of arterial circulation and impending gangrene are indicated by the following tests: (1) *Capillary Circulation:* The blood is pressed out of the skin or from under the nails, and the rapidity of the return of color noted. Delayed or absent return is due to lack of circulation. (2) *Production of Artificial Hyperemia* (*Moskowicz test*): The limb is emptied by elevation, an elastic bandage or tourniquet applied for ten minutes, and then taken off. The normal limb flushes down to the toes, the obstructed one only to the level where circulation ceases. This test is a guide as to the point of amputation. Hyperemia is immediately shown in the part having a good circulation; develops slowly in parts with impaired circulation, which are subject to gangrene; and is absent from the dead portion. (3) Matas compresses the main artery after removing the tourniquet to determine the degree of collateral circulation. (4) The condition of the circulation may also be shown by noting the degree of hyperemia following *rigorous friction* (Sandrock); this is very dangerous with thrombosis.

Pulmonary Tuberculosis.—Peripheral venous thrombosis occurs in 3 per cent. of advanced cases. Arterial thrombosis is rare, and chiefly involves the pulmonary, femoral, axillary, and subclavian vessels.

Pneumonia.—As a rather rare sequel, thrombi form chiefly in the lower extremities, especially in the femoral artery, and give a mortality of 20 per cent.

Influenza.—Thrombosis is not uncommon, usually involving the femoral vein, the veins of the upper extremities or, occasionally, the cerebral sinuses.

Postoperative Thrombosis.—This follows about 1 per cent. of abdominal sections, chiefly in the middle aged in association with a heart lesion, varicose veins, exhaustion, decubitus, or the pressure of abdominal tumors. A thrombus may develop as an extension from the deep epigastric vein (J. G. Clark). It usually occurs after an aseptic operation between the eighth and fifteenth days, and chiefly involves the left femoral vein. Albuminuria is present in 41 per cent. Thrombosis of the pulmonary artery is the common fatal form, usually causing death within fifteen minutes. The symptoms develop with great suddenness, usually in patients apparently making a satisfactory convalescence from operation, often as they are about to leave the bed or go home. A preceding increased pulse rate, with slight evening fever and lowered blood-pressure, is somewhat suggestive of an impending pulmonary thrombosis. The patient is abruptly taken with great dyspnea, intense pallor, rapid, weak action of the heart, and almost invariably dies within a few minutes.

Appendicitis is followed by arterial thrombosis in about 2 per cent. of the cases, usually between attacks, and after the catarrhal form.

Septic pylephlebitis, in which the portal vein is filled with pus and purulent thrombi, with secondary abscesses of the liver, occurs in less than 1 per cent. of the septic forms of appendicitis, from the direct connection between the appendicular, the ileocolic, the superior mesenteric vein, and the portal system. There are sharp chills, sweat and fever, pain and tenderness over the trunk of the portal vein under the border of the right rectus, with tenderness, uniform enlargement of the liver and spleen, rapid emaciation, occasionally jaundice, and death usually in from three to six weeks.

Diagnosis.—Pylephlebitis is to be differentiated from malignant endocarditis, pneumonia, empyema, and subdiaphragmatic abscess. In case of doubt as to the presence of multiple abscesses, an abdominal exploration should be made.

Prognosis.—This depends upon the location of the thrombus and the degree of associated infection. Pulmonary emboli are promptly fatal. Mesenteric thrombosis is fatal in about 8 per cent.; pylephlebitis, in 98 per cent.

Peripheral thrombi involving the extremities are usually followed by recovery, the prognosis being better in the aseptic type.

Mesenteric thrombosis involves the superior mesenteric artery more often than the inferior or the vein. The superior mesenteric artery gives off the inferior pancreaticoduodenal, the middle colic, right colic, ileocolic, and terminal branches to the cecum and appendix, supplying 8 meters of intestine. The inferior mesenteric artery supplies the descending colon. The duodenum, having two sources of blood-supply, is rarely jeopardized.

Pathology.—Single or multiple hemorrhagic infarcts are produced, involving a few inches or several feet of intestine. In one of our patients two sections (one 1.3 meters and the other 4 meters in length) were gangrenous. Gangrene usually develops within forty-eight hours. The condition may be acute, subacute, or chronic. The collateral circulation rarely may develop in an acute case, and eventually fail in a chronic one, or vice versa. One or more areas of omentum may be involved. As a rule, there is rapid necrosis and a secondary fatal peritonitis.

Etiology.—The disease especially attacks men between forty and fifty, with endocarditis or arteriosclerosis.

Symptoms are sudden, violent, diffuse abdominal pain with collapse, subnormal temperature, and signs of ileus. Bloody stools or vomitus occur in 41 per cent. and generalized tenderness is present in two-thirds of the patients. There is leukocytosis, a late temperature, palpable mass, evidence of free fluid, and early peritonitis.

Diagnosis.—Acute pancreatitis and perforated peptic ulcer should be differentiated from mesenteric thrombosis, which should always be suspected when an acute ileus occurs in a middle-aged man with endocarditis. The passage of altered blood with mucus from the bowel, blood-stained vomitus, or a previous history of heart disease or angina favors the diagnosis of thrombosis.

Fig. 42.—Gangrene from thrombosis of the femoral artery. Early pallid stage preceding the black color and mummification.

Prognosis is bad, the mortality without operation being over 90 per cent., and with early operation, 60 per cent.

Treatment.—Immediate operation (best under local anesthesia reinforced, if necessary, by a little ethylene or nitrous oxid-oxygen) is indicated. The necrotic bowel should be treated by resection and anastomosis or, if the patient is in desperate condition, by a temporary enterostomy, and isolation of the affected loop of bowel by gauze. The intestines should be carefully explored to make sure that other infarcts are not overlooked.

Internal Jugular Vein.—This is thrombosed chiefly from purulent middle-ear disease, and is involved secondarily as an extension of a thrombosis of the petrosal or sigmoid sinus or of a thrombosis of the innominate vein. Carcinoma, tuberculosis, syphilis, pyemia, and malaria may also be responsible.

Symptoms.—There is a painful, cord-like induration of the vein with dilatation of the collateral branches, restriction of the movement of the head, infiltration and edema of the adjacent tissues of the neck, and later reddening of the overlying skin. Softening and the formation of an abscess may follow.

Prognosis.—When occurring as a complication of sinus thrombosis, it is grave; when occurring as a terminal factor in an otherwise fatal malady, it is hopeless.

Treatment.—If not the result of an otherwise hopeless condition, an incision should be made into the vein and also into the affected sinus, and drainage instituted. Ligation of the vein proximal to the thrombus, curettage, irrigation, or any other unnecessary traumatism should be avoided as tending to produce secondary embolism. The mortality of the condition has been greatly increased by meddlesome surgery. General anesthetics, and those that increase the blood-pressure, should be carefully avoided; local or regional anesthesia should be used.

Arterial Thrombosis of the Extremities.—When due to embolism, there is acute violent pain in the limb which becomes white and corpse-like, then mottled, and finally—if the circulation is entirely arrested—black. Sensation and motion are lost, the involved artery is felt as an indurated, painful cord, free from pulsation, as are the vessels below.

Prognosis.—Death may follow the original shock, or the toxemia and exhaustion from the chronic gangrenous process. With untreated gangrene, a line of demarcation and spontaneous separation may occur. (See Fig. 42.)

Treatment.—Elevation, local warmth, and complete rest, with amputation for gangrene as soon as a line of demarcation forms.

EMBOLISM

Embolism is an intravascular obstruction from the lodging of a foreign body. Circulating foreign bodies which produce embolism are termed *emboli*.

Varieties.—(1) *Simple*, mechanical, or aseptic; (2) *specific*, infectious, or septic.

Composition.—(1) *Portions of thrombi*, as in verrucose endocarditis; (2) *fat-emboli*, as from fractures of long bones; (3) *air-emboli*, as from wounds of the veins in the neck; (4) *pigment-emboli*, as from melanemia; (5) *anthracotic emboli*, as from advanced anthracosis; (6) *malignant emboli*, portions from malignant tumors; (7) *micro-organismal emboli*, as in certain infectious diseases, and (8) *parasitic emboli*, as caused by the *Strongylus armatus* in mesenteric vessels of the horse.

Seats.—Emboli usually pass through the left carotid and middle cerebral, the left iliac, and right pulmonary arteries. In the brain, they usually lodge in the artery of *corpus striatum*. They are rare in mesenteric vessels.

Results.—1. Inflammation of the vessel.

2. Interruption of the circulation leading to: (a) Thrombosis; (b) atrophy; (c) necrosis; (d) aneurysmal dilatation, especially in the brain; (e) infarction; (f) gangrene, and (g) abscess from septic embolus.

Fat-embolism.—Etiology.—Fat-embolism occurs after contusion, fracture, or crushing injury of the long bones, forcible correction of contractures and, occasionally, from an operation upon a very obese patient. It is rare in

infants and old age, and is most common after fractures in the long bones or forcible bloodless correction of deformities about the knee with compression of the spongy epiphyses. The liberated fat may reach the blood through the lymphatics or perhaps, more rarely, directly enter open blood-vessels, producing embolism and infarction in the minute vessels of the lung.

Symptoms develop within twenty-four or forty-eight hours after injury. If pulmonary embolism with hemorrhagic infarction occurs, there is anxiety, air-hunger, dyspnea, rapid respiration, cough, hemoptysis, pallor followed by cyanosis, râles heard over the chest, and circulatory failure with feeble, rapid, and irregular pulse. If the fat passes through the lungs to the brain and heart, muscular cramps, delirium, convulsions, vomiting, paralysis, coma, fall in blood-pressure, and degeneration of the heart-muscle result. Fat-droplets in the urine and fever may be present.

Prognosis should be guarded and depends upon the extent and location of the embolic particles.

Prophylaxis.—Careful immobilization after fracture, accurate reduction of the fragments, avoidance of undue traction, crushing, or manipulation of the tissues of obese patients during operation.

Treatment.—Maintenance of circulation and body temperature. The patient should be placed in a semireclining position, and 10 minims of epinephrin given by intramuscular injection to overcome the acute condition. Large doses of the slower-acting digitalis are to be given by rectum, the subcutaneous tissues, or veins, together with saline infusions into the subcutaneous tissues and veins.

Embolectomy or *thrombectomy*, the surgical removal of the embolus or thrombus, should be considered immediately after thrombosis or embolism in an important accessible artery. The artery is exposed, opened, and the thrombus or embolus extracted with the least possible traumatism, under local or spinal anesthesia; never general anesthesia. The opening in the vessel is to be immediately sutured with fine arterial silk. Usually the thrombus promptly re-forms from changes that have taken place in the intima of the vessel. Hence, embolectomy or thrombectomy has rarely been successful. It should only be considered where the obstruction is recent. A ligation of the associated vein reduces the danger of gangrene. If gangrene occurs, amputation should be done as soon as the line of demarcation is evident.

Pulmonary Embolectomy or Thrombectomy (Trendelenburg's Operation).—As patients often live fifteen minutes after the first symptoms of pulmonary embolism, Trendelenburg has advocated opening the pulmonary artery and removing the obstruction.

Where embolism is feared, the necessary instruments are kept ready for use at the bedside. A skin incision is carried along the left sternal edge from the first to the third rib, a horizontal incision continued from this along the second rib. The skin and muscle flaps are raised with the resection of the second and, at times, the third rib, to a point well beyond the costochondral junction. The internal mammary vessels are avoided. The pericardium is opened, through the pleura, in front of the phrenic nerve, which is also to be avoided, and a rigid knobbed hook curved around the aortic and pulmonary artery, a strong rubber tube affixed and the instrument withdrawn, leaving the tube in place. By the rubber tube both vessels are pulled forward and controlled. The visceral layer of the pericardium and fat over the pulmonary arteries is excised, so that the vessel cannot later

slip back within the serous covering. Through an incision along the axis of the pulmonary artery, 10 mm. long, a fine curved dressing-forceps is introduced into the branches of the pulmonary artery and the clots extracted. The aorta and the pulmonary artery must not be constricted more than three-quarters of a minute. If uncertain as to complete removal of all clots, the incision should be temporarily closed with a special narrow clamp, the constriction relieved, and the procedure repeated later. In suturing the artery, forceps (springing outward and having a small hook projecting from each tip) are introduced between the ends of the opening, the vessel drawn forward, and a flat hemostatic clamp so applied behind the forceps that the edges of the incision project a little between the branches of the forceps. The blood-stream then travels behind the occluded slit, which is quickly closed by interrupted or continuous silk stitches. The wound is finally closed without drainage. Although Trendelenburg had no permanent recovery, Kuschner was successful, in 1924, in relieving a massive pulmonary embolism the third day after a herniorrhaphy. In this patient the pulmonary artery was clamped for forty-five seconds.

Venous thrombosis usually begins in the femoral or iliac or, more rarely, in the saphenous vein. It has also followed the injection of bismuth paste into the cavity of the chest or a wound. The thrombus may spread and involve the epigastric, iliac, or saphenous veins, or the veins of the pelvis. After childbirth, abdominal section, operation on the kidneys or ureter, or especially, for fibroid tumors of the uterus, femoral thrombosis not infrequently occurs during the second or third week.

Symptoms.—The thigh and leg suddenly become painful, tender, pale, and swollen, with greatly reduced function (*phlegmasia alba dolens, milk-leg*). The femoral or the internal saphenous vein may be palpable as a tender, firm cord. The condition slowly subsides after two or three weeks, but some edema may persist.

Prognosis.—Favorable as to life if complete rest, without massage, operation or manipulation, is followed. Edema, heaviness, and pain in the leg, increased by exertion, may continue through the patient's life if many veins have been thrombosed and become obliterated. If the thrombus is infected, abscesses form, which discharge or may be opened through the skin.

Treatment.—With the onset of venous thrombosis, absolute rest in bed is essential, with the leg elevated and protected. Evaporating lotions or hot fomentations give a degree of comfort. Massage and manipulation may dislodge a portion of the clot, causing secondary pulmonary embolism and sudden death. Operative exposure of the vein for ligation or removal of the thrombus is hazardous, often followed by a fatal shower of emboli, and should never be undertaken. After several days and with the subsidence of the acute symptoms, a 2 per cent. yellow oxid-of-mercury ointment is to be substituted for the moist dressings, the leg being wrapped in cotton, evenly bandaged, and kept elevated. Abscesses should not be incised until fluctuation is evident, and then only with a sharp knife, without trauma or manipulation and without curetting, squeezing, or packing. After firm organization occurs, the patient is permitted to go about with a well-fitted elastic bandage or stocking.

CHAPTER VII

NECROSIS AND GANGRENE

NECROSIS

Necrosis is death of a portion of the living organism, either a member, an organ, or a tissue.

Etiology.—(1) *Local injury:* mechanical, chemical, thermal, or bacterial. (2) *Vascular obstruction*, as in anemic necrosis or congestive necrosis. (3) *Trophic disturbances*, as in decubitus.

Varieties.—1. **Molecular Necrosis, Cellular Death:** (a) *Caries*, a molecular necrosis of bone or tooth. (b) *Liquefaction necrosis* or *colliquation necrosis*, in which a puriform liquid is produced.

2. **Massive Necrosis, Molar Necrosis, Necrosis en Masse:** (a) *Coagulation necrosis*, death with coagulation or condensation. (b) *Sphacelation* or *sloughing*—a dead solid mass of soft tissue (*sphacelus* or *slough*) separates from adjacent living tissues. (c) *Sequestration*—a solid mass of bone (*sequestrum*) separates from the adjacent living bone. (d) *Gangrene*, massive death of all the constituents of a part with putrefaction. The tissues adjacent to the dead part show inflammatory reaction.

Liquefaction Necrosis.—In death with liquefaction, the cells swell, fail to stain, and liquefy. The fluid is mainly supplied by the liquefaction of the intercellular substance, and by infiltration and exudation of fluid.

Etiology.—(1) *Ischemia*, especially in the *brain*, as from embolism with acute softening and cyst formation. Of the *stomach*, *gastromalacia* from the digestion of anemic areas. (2) *Superficial burns*, the vesicle formation is aided by the liquefaction of cells. (3) *Suppuration*, the pus aiding in the liquefaction.

These liquid products are either absorbed or, more frequently, have to be evacuated by incision or pointing.

In *sphacelation* and *sequestrum formation* the mass of dead tissue is separated from the living by liquefaction necrosis.

Coagulation necrosis, or death with condensation, occurs in (1) *coagulation of the blood*, as in the formation of thrombi, emboli, and clots; (2) *mucous surfaces*, as in pseudomembranes; (3) *internal organs*, as in infarcts and in certain granulomas; (4) *muscles*, as in the infections from the gas bacillus and other organisms.

Pathology.—There is fibrin formation from the union of fibrinogen, fibrinoplastin, and fibrin ferment derived from the blood, degenerating tissues, and bacteria. Secondary fatty degeneration may produce (1) a cheesy substance, *caseation*, *cheesy necrosis*, *tyromatosis*, or (2) a milky fluid, *pathologic milk*. The area is firmer, drier, and grayish or yellowish white. The disintegration of blood causes a reddish, brownish, greenish, or blackish discoloration. In the later stages the area is softer, moister, and at times cheesy.

GANGRENE

Gangrene is massive death of a part of the body with putrefaction. It involves parts accessible to the air or to infection, as the extremities, face, generative organs, the respiratory and the intestinal tracts. Thus, we speak of gangrene of a finger, hand, leg, foot, arm, genitals, face, lungs, appendix, intestines, urinary bladder, gall-bladder, and the like.

Moist gangrene occurs in parts which are moist and congested at death. The part is swollen, greenish or blackish, cool, moist, soft, and emanates a foul gas. The surface shows blebs, non-adherent epidermis, and the tissues may crepitate on pressure.

Etiology.—1. *Bacterial infection* and intense inflammation, as in gas bacillus gangrene, gangrene of the lung following pneumonia, noma of the face or genitals.

2. *Trauma*, as after a devitalizing injury.

3. *Vascular obstruction*, especially venous, as in strangulated hernia, occasionally in the foot after ligation or division of the femoral or popliteal vessels, or from arteriosclerosis or thrombo-angiitis obliterans.

4. *Diabetes* (diabetic gangrene), in which arteriosclerosis is associated with a lowered resistance of the tissues.

5. *Trophic disturbances*, as in decubitus or bed-sore, from certain spinal affections.

Dry Gangrene.—*Mummification* occurs in parts anemic or dry at the time of death. It is normal in the umbilical cord. The part is dry, shriveled, blackish, leathery, and friable, and the odor is much less intense than in moist gangrene.

Etiology.—(1) *Arterial obstruction*, as in senility (senile gangrene) from arteriosclerosis or thrombo-angiitis obliterans, or from ligation of a main artery. (2) *Arterial spasm*, as in Raynaud's disease, ergot poisoning. (3) *Certain drugs*, as carbolic acid, applied for a considerable time, even in dilute solution. (4) *Frost-bite* may cause either dry or moist gangrene, according to whether the part dies in ischemia or congestion.

Direct gangrene is due to the direct destruction of tissue from injury, pressure, chemical action, Roentgen or other radiant energy, burns, scalds, frost-bite.

Indirect gangrene is due to interference with the blood-supply of the part, as in senile, presenile, diabetic, postfebrile, Raynaud's, ergot, ainhum, embolic gangrene, gangrene from ligation, thrombosis, or other obstruction of the main artery or vein of a part.

Mixed or *microbic gangrene* results from the action of bacteria and their toxins, and is often associated with vascular thrombosis, as in gas gangrene, hospital gangrene, and noma.

After the development of gangrene (1) a *line of demarcation* forms, which is the junction of the living and dead tissues, followed later by the (2) *line of separation*, a deepening groove of ulceration, liquefaction, necrosis and granulation, gradually separating the dead from the living tissues. Proximal to the line of demarcation the tissues are inflamed.

Symptoms.—With the onset of gangrene there is extreme neuralgic pain in the part, followed later by loss of sensation and the complete death of tissues.

Until mummification or putrefaction interferes with mobility the fingers and toes may be deliberately moved through the long tendons attached to higher living muscles. From *dry gangrene* there is limited absorption and, often, limited constitutional disturbance, although living bacteria may enter the body at the line of tissue separation.

In *moist gangrene* the greenish-black color is caused by the formation of sulphite of iron from decomposition of blood-pigment. Moist gangrene and microbic gangrene are more prone to spread than dry gangrene, are associated with toxic bacterial absorption, and more acutely menace life. With moist gangrene, early operation is desirable; in dry gangrene, it may often be deferred.

Senile gangrene (*arteriosclerotic gangrene, gangrene of the aged*) results from the diminution in the supply of blood to a part from an obliterative arteriosclerosis. It is much more common in men than in women, especially in syphilitics, alcoholics, and those with other causes of arteriosclerosis. It usually

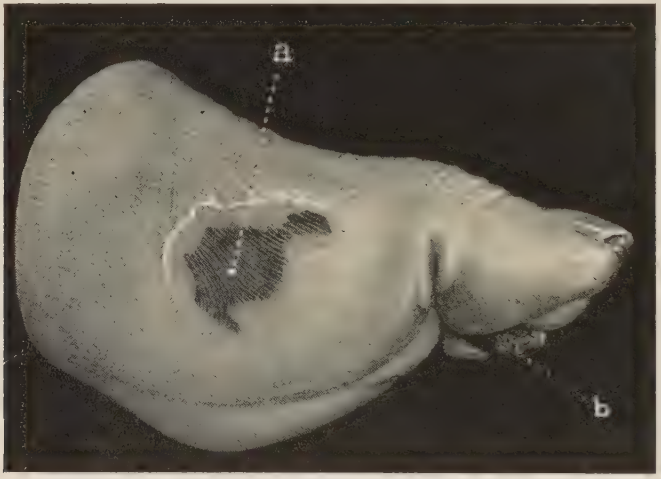


Fig. 43.—Senile gangrene of the foot and small toe, early stage, from atheromatous occlusion of the femoral artery: *a*, *b*, Dark gangrenous parts.

begins in the great toe, gradually spreading to the heel or leg. It often follows slight injury, as the cutting of a toe-nail or corn, an abrasion from a tight shoe, a frost-bite or burn. Frequently a thrombosis in a thickened or sclerosed popliteal or tibial artery starts the process. The obstruction usually is in the upper part of the posterior tibial artery. The other foot may be simultaneously or consecutively involved.

Symptoms.—Prodromal signs are *coldness*, *tingling*, and *formication*. The gangrene begins with a dark blue spot, pallor and bluish mottling, a blister containing blood-stained fluid, or a chronic ulceration about the nail, and severe deep-seated, neuralgic, cramp-like pains. Gradually the part becomes dry, shriveled, cold, and insensitive. The line of demarcation, if fixed and quickly formed, suggests that the circulation is satisfactory above. If slowly formed, irregular, and not fixed, it indicates that the circulation above is poor. The tendency is for the gangrene to become arrested at a larger joint: of the great toe, at

the metatarsophalangeal joint; of the foot, at the tarsometatarsal or the ankle-joint; of the leg, just below the knee. The dorsal usually is more affected than the plantar side; the skin more than the bone and muscle.

Prophylaxis.—This includes the treatment of arteriosclerosis, plus protection of the feet of old people from slight injuries and infection. Protection from cold, the heat of hot-water bottles or fire, and pressure sores is important.

Treatment.—Senile gangrene is best treated by early operation, before the patient has become exhausted or toxic. If the body of the foot has been invaded, it usually is necessary to amputate through the lower third of the thigh, although a preliminary section, without a tourniquet, 4 inches below the knee may be tried to determine the permeability of the anterior and posterior tibial arteries. Usually these vessels will be found almost or completely occluded through atheroma and calcareous deposits, or embolism.

Fig. 44.—Diabetic gangrene, early stage. Beginning necrosis of the foot. Amputation required through the lower thigh.

Only when there is pulsation felt at the ankle should amputation below the knee be considered.

Diabetic gangrene frequently occurs in women and in men over fifty years of age. With diabetes the tissues are more susceptible to infection, while ischemia from a high-grade arteriosclerosis and, at times, thrombosis is associated. The gangrene begins gradually, usually after a slight injury, especially of the toes. The part becomes swollen, dusky red, edematous, and very painful. Necrosis spreads to the subcutaneous tissues more than to the skin, with suppuration and decomposition. The overlying skin first becoming reddened, then necrotic, with the formation of openings and discharge.

Prognosis.—The age and the intense metabolic disturbance, the high-grade arteriosclerosis, and a tendency to a spreading infection render diabetic gangrene very dangerous and often fatal.

Treatment.—When confined to the toes, the part should be elevated, in a warm chamber, exposed to the electric light, kept clean, and coated with resin cerate or petrolatum to facilitate drainage. Great care should be taken that the part is not overheated or traumatized. Irritating antiseptics, as iodoform, phenol, or bichlorid solutions, and probing, packing, curetting, or squeezing should be avoided. If the gangrenous process spreads into the body of the foot, amputation through the lower third of the thigh, preferably under spinal or ethylene anesthesia, should promptly be done. At times the other leg becomes gangrenous after the first.

The diet should be carefully selected, but ample; the hyperglycemia determined by frequent tests and held within safe limits by the use of *insulin*.

Embolic gangrene results from the sudden occlusion of the main artery of a part by a thrombus or embolus.

Fig. 45.—Diabetic gangrene of the foot, moist type, with bleb formation and beginning mummification of the toes. Amputation through the lower thigh required.

Etiology.—The obstruction occurs during the convalescence from typhus, typhoid, and exanthematous fevers, and in frost-bites where it involves toes, fingers, nose, or ears.

Symptoms.—There is sudden pain and at times shock, the limb becomes cold, pale or mottled (white gangrene), numb, insensitive and without voluntary motion, and gradually shrivels and darkens.

Prognosis.—The extent of the gangrene depends upon the situation of the obstruction. If at the *bifurcation of the abdominal aorta*, there is symmetrical gangrene of both legs to the inguinal ligaments; if of the *external iliac* or *femoral artery* above the origin of the profunda, to the middle or upper third of the

thigh; if the obstruction is of the *femoral* below the origin of the profunda or of the popliteal, gangrene does not invariably occur. If at the *bifurcation of the popliteal*, the gangrene tends to spread and to involve the foot and lower leg; if of the *axillary artery*, to involve the midbrachial region; if at the *brachial bifurcation*, to extend to the middle third of the forearm.

Treatment.—(1) *Immediate Embolectomy:* The artery is exposed, opened, and the clot gently withdrawn, the opening being closed with fine arterial silk. As a rule the intima is so damaged that the clot promptly re-forms. The risk of gangrene is not increased by simultaneous occlusion of the vein and the artery. In milder forms the collateral circulation may be established with recovery. (2) *Elevation, rest, warmth, electric-light bath.* (3) *Amputation.*

Strangulation of a part occurs from: (1) Prolonged application of a tourniquet. (2) A tight bandage, or splints, plaster case or bandage applied with inadequate allowance for secondary swelling of the tissues. (3) A ring or cord applied to the finger or penis. (4) Prolonged application of a cupping-glass.

Gangrene or *Volkmann's contracture* follows the arrest of the circulation in a part for more than two hours. All bandages and cases should be so applied as to allow for secondary swelling, by ample padding and by even, non-constricting application. It is safer to apply the supporting bandage from the tips of the fingers or toes to a point above the lesion, so that the tissues distal to the lesion are supported and prevented from swelling. Tight rings are removed from the finger: (a) by reducing the swelling by the application of iced water; (b) by thoroughly lubricating the finger with soap; (c) by a tight, even, close wrapping of the finger from the tip to the ring with a fine silk string, the end of which (when the ring is reached) is passed under the ring and unwound from beneath the ring with traction, so that the ring gradually slips from the finger, as the string is unwound. If this fails, a protecting strip of metal is slipped under the ring, which is then divided by a narrow file or cutting forceps.

Volkmann's contracture is a limited form of necrosis, in which degeneration of muscles and other soft tissues occurs with subsequent atrophy and contracture, but without gangrene.

Treatment.—Prophylaxis: Joints should not be flexed after the application of a bandage. The toes and fingers should be exposed and watched for circulatory changes after bandages or fixed dressings have been applied. Any constriction should be released, the skin being cleansed with alcohol, the part elevated, supported, and kept warm.

Thrombo-angiitis obliterans *(juvenile gangrene, presenile gangrene, presenile spontaneous gangrene, Buerger's disease)* is due to the primary formation of obdurating thrombi in the arteries and veins, with ischemia and a tendency to gangrene.

Pathology.—Soft, red thrombi develop (usually in vessels of medium caliber) in the legs, or at times in the arms. The thrombi spread along the vessel and become vascularized by capillary buds from the media and adventitia. Subsequent canalization of the organized thrombotic tissue may occur. An associated periarteritis and periphlebitis with agglutination of arteries, veins, and nerves also occurs. The blood of affected Japanese laborers (who live on rice and legumes) shows increase of calcium, and normal carbon-dioxid, cholesterin, and blood-sugar content.

Etiology.—(1) *Male sex*, almost unknown in women. (2) Race, *Jews* and *Japanese*. (3) Age, *twenty* to *thirty-five*. (4) *Excessive cigarette smoking*.

Symptoms.—(1) *Vasomotor:* hyperemia, local syncope, and asphyxia. (2) *Sensory:* pain, hyperesthesia, and paresthesia. (3) *Trophic:* dystrophia of the skin—atrophy, ulceration, gangrene.

In the earlier stages: *Acrocyanosis; erythromelia*, blue or cyanotic extremities, redness of extensor surfaces of arms and legs; *acroparesthesia*, perverted sensation in extremities; *erythromelalgia*, redness and neuralgic pain of distal part of extremity (Weir Mitchell, 1872); *intermittent claudication* (intermittent, painful limp), occurs from the ischemia. Exertion is followed by pain, tingling, cramp, weakness, and paresis in the legs; relieved by rest.

Fig. 46.—Dry gangrene of toes and anterior part of foot from thrombo-angiitis obliterans.

Clinical Picture.—A Russian or Polish Jew, who for many years has smoked twenty or more cigarettes daily, develops numbness and coldness in his foot during cold weather, with blanching alternating with dark red suffusion or a livid cyanotic color, followed by a drawing sensation, sense of sticking of pins, burning and excruciating, cramp-like pain, which may prevent walking. The soft tissues waste, the part is cold, and pulsation cannot be felt over the anterior or the posterior tibial artery. The condition may improve during warm weather, but tends to increase to necrosis of the skin and finally gangrene of the toes and foot.

Prognosis.—The disease tends to progress, and to relapse after improvement. Under treatment, periods of relief for months or years are obtained, except in those with far advanced disease, which requires amputation.

Treatment.—1. *Avoidance of tobacco*, especially cigarette smoking.

2. *Hygienic Supervision:* (a) Ample food with excess of green vegetables, fruits, cereals, and milk. Meats, coffee, tea, salt being restricted. (b) Ample sunshine and fresh air. (c) Excess of water by mouth or by duodenal tube (4000 to 8000 c.c. daily). (d) Laxatives and colonic irrigation for constipation. (e) Daily baths. (f) Removal of septic foci in mouth, pharynx, nose, or elsewhere. (g) Gentle manicuring or other necessary attention to the nails, avoiding all trauma to the soft tissues. (h) Protection from cold. Felt insoles and wool-lined loose boots.

3. *Rest in bed*, with the foot or other affected part elevated under a bed-tent and constantly exposed to the heat and light of a 75- to 200-watt electric light. To prevent drying, the skin, especially necrotic and ulcerated areas, is kept coated with compound resin cerate or lanolin.

4. *Venotherapy.*—Large, repeated intravenous injections of various fluids are useful in relieving pain and improving the nutrition of the affected part, including: (a) *Salt solution* (0.9 per cent. sodium chlorid or, better, Ringer's solution). From 300 to 1000 c.c. are very slowly infused by gravity every four to six days. (b) *Sodium citrate* (W. A. Steel), 2 per cent. in 300 to 500 c.c. of saline solution, infused every four to seven days. (c) *Potassium iodid*, 2 gm.; *sodium salicylate*, 1 gm., and water, 20 c.c., injected every two to four days.

5. *Amputation*, limited to the affected part, is used for the removal of necrotic parts. High amputation is used when the gangrene is spreading or extensive.

Symmetrical gangrene (*Raynaud's disease*) is a trophoneurosis due to spasm of the arterioles with recurrent vasomotor attacks, characterized by local arterial syncope, usually bilateral and symmetrical, affecting the fingers and toes, and excited by cold.

Pathology.—The gangrene involves the fingers, especially the index-finger, the toes, ears, nose, rarely the tongue or nates. It rarely extends to the wrist or above the ankle. The gangrenous areas usually are bilateral, small, symmetrical, dry, superficial.

Etiology.—Raynaud's disease chiefly occurs in women between eighteen and thirty years of age, who are anemic or chlorotic. It often is hereditary, is excited by cold, and does not occur in warm climates.

Symptoms.—Attacks which last a few moments or several hours and recur at intervals of months and years. Gastric, intestinal, and pelvic disturbances may precede an attack.

Stages.—(1) *Local syncope*, arterial spasm, the finger becoming white, numb, stiff, and insensitive; followed after a few minutes or hours by (2) *active hyperemia* with vasodilatation, redness, heat, throbbing, swelling, and severe burning, shooting pain. (3) *Local asphyxia*, the part becoming dull, livid, blue or black from reflux of venous blood, and cold, tender, and very painful. (4) This may subside, or pass into *dry gangrene*. The part develops bullæ with blood-stained fluid, is cold, painful, and turns black.

The fingers of both hands or the toes of both feet are usually affected simultaneously. The gangrene seldom spreads beyond the phalanges or deeper than the skin. The slough, comparatively small and superficial, may take some months to separate. The condition may recur each winter.

Associated Conditions: Paroxysmal hemoglobinuria, urticaria, arthritis, albuminuria, or mild attacks of acrocyanosis. The hyperemic stage resembles erythromelalgia.

Diagnosis.—Arteriosclerotic gangrene occurs in middle or advanced life in persons with evident arterial disease.

Buerger's disease is presenile, and involves the feet or hands of Jewish or Japanese men who are heavy cigarette smokers. It is associated with arterial obstruction. The gangrene is not, as a rule, symmetric, but consecutive, deeper, and more destructive.

Cervical rib may cause a superficial terminal gangrene of the fingers, usually unilateral, and with other evidence of the cervical rib.

Fig. 47.—Gangrene of finger from application of dilute carbolic solution—treated by skin-grafting

Treatment.—(1) Avoidance of exposure to cold, ample nutrition, the use of passive hyperemia. (2) Periarterial sympathectomy (Leriche), the removal of the outer coat of the main artery of the limb for a distance of 4 to 7 cm., is especially indicated. (3) Removal of necrotic tissue and skin-grafting may be required.

Gangrene from ergot results from the spasmodic contraction of arterioles, and occurs in debilitated persons from the eating of large quantities of rye bread contaminated with *Claviceps purpurea*, the *ergot of rye*. It also follows the prolonged medicinal use of ergot. It attacks the toes, fingers, ears, and nose. The gangrene is preceded by formication, numbness, and pain, and is of the dry variety. Scurvy and alcoholism predispose, and trivial

injuries, which easily occur owing to the anesthesia present, often start the gangrenous process.

Treatment includes a generous diet with full supply of vitamins, elimination by baths, diuretics, laxatives, avoidance of rye bread, and ergot, perarterial sympathectomy, removal of necrotic tissue, and plastic operation or amputation.

Chemical Gangrene.—Mineral acids, caustic alkalies, and dilute solutions of carbolic acid applied as a wet surgical dressing cause gangrene. *Carbolic gangrene* especially involves the fingers of women and children, with thrombosis and necrosis. The part is pale, anesthetic, soft, later becoming dark and leathery. A line of demarcation forms and the dead tissue slowly separates.

Treatment consists in removing necrotic tissue and skin-grafting, or in amputation. The deeper tissues and bones may escape destruction and be saved.

Trench-foot, with necrosis and even gangrene, results from the combination of cold, moisture, and constriction. It frequently occurred during the Great War in the armies in France.

Bacterial Gangrene (*Phagedenic Gangrene, Hospital Gangrene*).—Acute infectious gangrene may follow injuries that vary in severity from a pin-scratch to a crush. The part rapidly becomes painful, swollen, edematous, tense, dull red or purplish, bullæ form, putrefactive gases develop in the tissues with emphysematous crackling. Red lines follow the course of the lymphatics up the limb. There is extreme prostration with small, rapid, feeble, and irregular pulse. Death may result in thirty-six to forty-eight hours.

Treatment.—(a) *Prophylactic disinfection* of wounds contaminated by earth, street dirt, stable refuse. (b) *Débridement* (*French*, to unbridle; more properly *épluchage*) is used to mechanically sterilize a wound by promptly excising all contaminated tissue, and especially to prevent or arrest gas gangrene. (c) *Early amputation* of the guillotine type should be used if the gangrene is progressive. The wound should be disinfected by the Carrel-Dakin treatment or by the constant application of solutions of potassium permanganate (1 : 200) or bromin (1 : 2000).

Gas Gangrene.—Bacterial gangrene, with the formation of gas in the secretions and tissues through the action of bacteria. *Bacillus aërogenes capsulatus* (*Bacillus perfringens*) was found in 82 per cent. of the cases of gas gangrene from wounds of war. Gas gangrene has also been ascribed to Pasteur's *vibrion septique*, Weinberg and Seguin's *Bacillus œdematiens* (*Bacillus histolyticus*), *Bacillus fallax*, Vincent's *Bacillus fusiformis*, and other anaërobes. The *Bacillus coli communis* and *pyogenic cocci* acting upon the tissues may prepare them for the action of the anaërobes.

Etiology.—Infection is favored by devitalization of the tissue and necrosis. The causal bacteria have been found in feces, earth, and clothing made of wool. The gangrene, therefore, usually develops in lacerated and contused wounds and compound fractures, especially when there has been contamination from soil, manure, street dirt, or wool.

Pathology.—The organisms spread between the muscle-fibers inside the muscular sheath. A clear toxic fluid is formed, the muscle-fibers undergo fibrosis, necrosis, and are invaded with the production of toxic gas and serous exu-

date, with tension and arrest of the circulation in the capillaries and other vessels. The muscle is friable, appears as if cooked.

Symptoms develop several hours after the infliction of a severe lacerated or contused wound, or gunshot wound.

The *wound secretion* is free, at first serous and hemorrhagic, soon becomes turbid and dark brown, and acquires the intense, putrid odor of decaying meat. Later it may show abundant gas-bubbles.

Skin is ischemic, mottled, of a khaki color, crepitating on palpation. The muscles, at first hemorrhagic and friable, become brick-red, then green or black, and do not bleed on section.

Constitutional Symptoms.—A rise of temperature occurs six to twelve hours after the injury, with increase of pulse rate and increasing pain in the wound. There is tachycardia out of proportion to the temperature, acute anemia, shock, and delirium from the absorption of histamin.

Diagnosis is made early by the failure of the patient to react from the injury, the absence of bleeding or contraction of muscle, the crepitation of the tissues on palpation, the putrid, gas-filled wound secretion, showing on bacteriologic study the gas bacillus.

Prognosis.—Death may occur in forty-eight hours with a temperature of 104° to 107° F. Recovery, however, may occur after operation on a patient apparently moribund unless the trunk is involved.

Treatment.—1. *Prophylactic:* Early débridement, especially the excision of devitalized tissue and parts of muscle that have contacted with wool or animal products. Injection of perfringens vaccine should be given early.

2. *With the onset of the disease*, immediate débridement until bleeding contractile muscles are invaded, together with free longitudinal incisions to permit the escape of gas through the muscular aponeuroses, is indicated. If the process involves many muscles with massive gangrene, amputation, preferably by the guillotine method, should be used. If the entire limb is not involved, free incisions give better results than amputation. Operation should not be delayed because of the desperate and apparently hopeless condition of the patient.

3. *Constant application* of permanganate-of-potash solution (1 or 2 per cent.) or of Pilcher's solution (quinin sulphate, 1 gm.; hydrochloric acid, 0.5 c.c.; glacial acetic acid, 99 per cent., 5 c.c.; sodium chlorid, 17.5 c.c.; formol, 40 per cent., 1 c.c.; thymol, 0.5 gm.; alcohol, 90 per cent., 15 c.c.; water to make 1 liter. The quinin is dissolved in the acid, the sodium chlorid in the water, the thymol in alcohol, and is added last).

4. The polyvalent, mixed antitoxic sera (Bull and Pritchett, 1917) or perfringens antitoxin may be of value.

General treatment includes the free use of fluids by mouth, hypodermoclysis, and infusion: the use of glucose solution, or insulin and glucose for acidosis, and transfusion for the increasing anemia.

Cancrum oris or **noma** occurs in debilitated children, two to five years of age, during convalescence from scarlet fever, measles, or typhoid. It involves the cheek, mouth or, rarely, the vulva (*Noma pudendi*). *Cancrum oris* begins as an ulcerative stomatitis, with foul-smelling blood-stained saliva, deep ulceration of the cheek with edema and infiltration, followed by the appearance

Gas gangrene forty-eight hours after compound fracture of thigh from automobile accident. Symptoms of prolonged intense shock with local crepitation and blebs containing liquid and gas.

of an increasing dark area. The centre is black, blue, and gray with a surrounding reactionary, dark red area. Marked ulceration of the gums and floor of the mouth, falling of the teeth, and extreme prostration are often associated.

The **prognosis** is bad, death usually occurring from general toxemia or septic pneumonia. Secondary deformity follows from loss of soft tissues or necrosis of the jaws.

Treatment should include the maintenance of nutrition and vitamin intake; early excision by sharp knife or scissors; stimulation of the tissues by tincture of iodin; the frequent use of antiseptic mouth-washes, as permanganate of potash, 1 : 500, or liquor antisepticus, and exposure to ultraviolet light.

CHAPTER VIII

SHOCK

Syncope or **fainting** is a form of unconsciousness due to a sudden fall in blood-pressure or active vasomotor depression.

Pathology.—Vasomotor relaxation, fall in blood-pressure, depression of the heart and respiration, and muscular relaxation. The condition occurs reflexly from cortical impressions or from cerebral anemia.

Etiology.—Emotional shock from (1) *visual impressions;* (2) *auditory impressions* that bring terror, fear, sympathy, danger; (3) *sensory impressions,* suggesting pain, tumor, or hemorrhage; (4) *subjective ideas* of cancer, accident, poisoning, or terror of other serious illness; (5) *sudden raising of the head* in anemia, after hemorrhage, or during spinal anesthesia; (6) *traumatic injury,* solar plexus or cardiac blow, torsion upon viscera.

Predisposing causes are female sex, anemia, debility, hemorrhage, starvation, asthenia, excessive heat, unpleasant odors, crowding, and the induction of anesthesia.

Symptoms.—Pallor, dilatation of pupils, cold clammy sweat, coldness of surface, vertigo, nausea, vomiting, unconsciousness with relaxation of voluntary muscles, the patient becoming limp and falling to the floor.

Diagnosis.—Syncope is usually due to a sudden emotional reflex, and differs from shock in the absence of dangerous injury, the absence of exemia, and in the brevity of its duration. Syncope is distinguished from cerebral concussion by the absence of injury to the head and the shorter duration. It is diagnosed from hysteria, catalepsy, and malingering by the great pallor, complete muscular relaxation, unconsciousness, and absence of winking. In catalepsy and syncope there is insensibility to pain. Wardrop, in 1827, induced syncope by rapid phlebotomy in an overheated, congested room, and operated while the patient was unconscious. The persistence of unconsciousness for over a few minutes indicates an additional condition, such as shock, cerebral concussion, or compression.

Treatment.—Head in dependent position to overcome cerebral anemia; inhalation or the administration of ammonia, ether or, better, carbon dioxid (5 to 10 per cent.) in oxygen.

Shock.—*Exemia,* drained of blood (Cannon).

Shock is a profound depression of the vital processes, caused by injury, and characterized by reduction in volume of the circulating blood, with consequent fall of blood-pressure and change in the chemistry of the blood.

Primary shock occurs immediately after the injury.

Secondary shock develops after an interval of several hours. Shock results from mental or physical injury, or devitalization of tissue. *Surgical shock* occurs during operations, and results from rough, prolonged, and repeated manipulations, crushing or mangling of tissue, exposure of sensitive areas to air, cold,

chemicals, and deep or continued anesthesia, especially from chloroform, ether, or nitrous oxid with insufficient oxygen.

Henderson's theory of shock, although not accepted, is ingenious. He believes the injury produces: (1) Stimulation of the respiration (*hyperpnea*), which results in (2) a rapid loss of carbon dioxid from the blood (*acapnia*), which leads to (3) failure of the venopressure mechanism, and produces (4) *venous anoxemia*, tissue asphyxia, acidosis, and finally is followed by (5) *acute oligemia*.

Crile emphasizes the cellular changes in the central nervous system which he attributes to *noci* (harmful impulses) streaming in from the periphery. *Anoci-association* is a plan for blocking the flow of harmful impressions from the operative field to the centers.

Pathology.—There is reduction of blood-mass, the blood-serum transudes from the capillaries into the tissues, so that the blood is concentrated in the viscera and shows a higher cell-count. The capillaries, especially in the intestines, may be packed with blood-corpuscles. The blood-volume may be reduced 1500 c.c., or a reduction of from 52 to 85 per cent. of the normal volume of blood. The plasma is reduced to from 62 to 90 per cent. of the normal.

Fall in Blood-pressure.—The blood-pressure falls from the reduction in the blood-volume. Vasomotor tone of the vessels is present and often augmented, except in the terminal stages, when it may be lost. There is no splanchnic engorgement; the muscular and nervous mechanisms of the heart are competent, as shown by the rise in blood-pressure when the volume is made up, and the continuance of the heart-beat after respiration has stopped.

Changes in Blood Chemistry.—As the blood-volume is reduced, the volume-flow decreases. This impairment of the circulation is also accentuated by the increased viscosity of the blood, and the excess of blood-cells in the capillaries. Oxidation is reduced (anoxemia), and the lack of oxygen in the tissue leads to the formation of non-respirable acids, such as lactic and diacetic acid, which replace the carbonic acid in the sodium bicarbonate. The carbon-dioxid combining power of the plasma falls below 50 volumes per cent., thus there is a reduction in the alkali reserve, and an acidosis is produced. The tissues suffer from lack of food, water, and oxygen, especially the cells of the central nervous system. The small *pyramidal cells* of the cortex die after eight minutes' complete deprivation of oxygen, while the *Purkinje cells* show chromatolysis, and die in twenty to thirty minutes. The *cells of the medulla* are less sensitive; those of the *cord* and *sympathetic ganglion* die in forty-five to sixty minutes; and of *myenteric plexus* in three hours (Cannon). The degenerative changes of the central nervous system account for the apathy, the reduction in sensibility, and the reduction of the reflexes.

Hyperpnea is present when the carbon dioxid falls below 43 per cent. To maintain normal oxidation of the body, a blood-pressure of about 80 mm. of mercury is required. This approximately marks the critical level, below which the blood-pressure is no longer able to maintain adequate flow to the tissues, and explains why, during shock, a slight additional hemorrhage (*critical further bleeding*), an operation, chilling, or exposure (which further reduces blood-pressure) may cause the collapse and death of the patient.

The contracted capillaries open if there is lack of oxygen. The blood-sugar is normal or slightly increased; there is an increase of non-protein nitrogen and residual nitrogen in the blood, the urea and especially the creatinin being in-

creased. The urine shows an increase of acidity, apparent in ammonia content, acetone, and urea. Heat production is decreased, and may fall to 67 per cent. A leukocytosis up to 50,000, chiefly polymorphonuclear, is often seen during the first three hours, but may disappear in forty-eight hours. In late shock the usual rise of blood-pressure from asphyxia does not occur.

Burns.—The metabolic changes are similar to those seen in shock. There is an increase in the number of red blood-cells, a concentration of the blood, and enormous mobilization of the white cells, and death may occur from the toxic action of protein derivatives absorbed from the burned area.

Predisposing Causes.—*Age.*—There is relative resistance to shock during the first three weeks of life; thereafter, during childhood, there is a relative susceptibility to shock. Old persons develop shock more slowly than young adults, but recover less frequently.

Sex.—Women are slightly less susceptible than men.

Race.—The more intellectual races are more susceptible than the Negro, Indian, Oriental, or savage tribes; cultured and nervous persons more than the dull and phlegmatic.

Hemorrhage, starvation, exhaustion, cachexia, and toxemia are powerful predisposing factors to shock. Cold and exposure greatly increase shock, and may prevent recovery.

Exciting Causes.—*Trauma.*—Crushing, tearing, lacerating, contusing injuries produce more shock than clean-cut, incised wounds. The closer the injury is to the trunk, the greater the degree of shock. Traction, handling, and exposure of important viscera, especially the intestines, stomach, lungs, heart, or brain, produce more shock than the exposure or handling of less highly developed tissues. Injury of highly sensitive areas (such as sensory nerves, the testes, the palmar surface of the hand) causes more shock than injury of the parts less richly supplied with sensory nerves. The duration of the stimulus is very important, prolonged injury and prolonged operations causing more shock than a brief period of injury and short operations.

Thermal Causes.—Extensive burns, frost-bite, great chilling of the body.

Toxic Causes.—Caustic acids, alkalies, various poisons; liberation of pancreatic ferment, acute pancreatitis, the rupture of a gastric ulcer, the rupture of an abscess of the brain into the lateral ventricle.

Psychic Causes.—Fear, great nervous excitation.

Symptoms.—Persistently reduced arterial pressure; rapid, thready pulse, which may be imperceptible at the wrist; superficial, shallow, rapid respirations; pallid, grayish, or slightly cyanotic appearance; cold, moist, sweating skin; vomiting, restlessness at times, mental dulness, and apathy with retained conciousness; reduced sensitiveness to painful stimuli.

The patients may be divided into three clinical groups (Keith):

Group 1, Compensated: General condition good; weakness and pallor present, only a moderate hemorrhage has occurred; the pulse is from 90 to 110; the systolic pressure over 100 mm. of mercury; the blood-volume is not below 80 per cent. of normal, and the plasma-volume 80 to 90 per cent. of normal.

Group 2, Partial Compensation: General condition is poor, and the condition of shock very evident. Free hemorrhage usually has occurred; the patient

is pale, restless, thirsty; vomits; there is coldness, partial anesthesia of the surface. The pulse ranges from 120 to 140, and is difficult to count. The systolic pressure is below 90, usually between 70 and 80 mm. of mercury; the blood-volume is 65 to 75 per cent. of normal; the plasma-volume 70 to 80 per cent.

Group 3, Uncompensated: The patient is in very serious condition. He is restless and thirsty, but vomits on taking fluid. The skin is cold, the pulse rate is from 120 to 160 and difficult to determine, although rarely, in a terminal condition, the rate may fall below 100. The blood-pressure is under 60 mm. of mercury; the blood-volume below 65 per cent.; the plasma-volume from 62 to 70 per cent.

Prognosis depends upon the maintenance of blood-pressure and oxidation. From lack of oxygen the capillaries dilate. McKesson's rule, that shock is shown when the pulse-pressure becomes less than one-half of the diastolic pressure, is misleading. According to Brechot and Claret a pulse-pressure above 25 mm. of mercury gives a favorable prognosis; at 25, a questionable prognosis, and below 25, an unfavorable outcome is indicated.

Toxemia from Devitalized Tissue.—In extensive crushing wounds toxic substances may be absorbed from the mashed tissues, producing secondary shock, which is prevented by interrupting the circulation from the damaged part (Cannon). In secondary shock the prevention of absorption from devitalized tissue is most important. Acidosis is of less importance than the underlying deficiency in oxidation.

Shock and Hemorrhage.—While shock may occur without hemorrhage, the loss of blood produces or intensifies the condition of shock. After hemorrhage the blood-volume is rapidly regained, with a reduction of hemoglobin and corpuscles, and an increase in leukocytes; while in shock the blood-volume is reduced, with a relative increase in hemoglobin and corpuscles, and a marked reduction in metabolism.

From hemorrhage, 20 per cent. and then 10 per cent. of the blood may be removed with little change in blood-pressure, but a third bleeding may break the compensation, cause a great fall in blood-pressure, and death. In shock, especially, a small additional bleeding may be fatal.

Anesthetics and Shock.—The administration of ether or chloroform is dangerous during shock. Ether fails to stimulate the bulbar centers, and depresses the heart from the beginning (Cattell). Nitrous oxid-oxygen, in ratios from 6 : 1 to 4 : 1, produces as great a fall in blood-pressure as does ether, but may be given in a ratio of 3 : 1 without fall in blood-pressure.

Spinal anesthesia produces such a fall in blood-pressure as to be very dangerous. It should be avoided, or used only when it can be guarded by the simultaneous injection of dilute solution of adrenalin into a vein or the tissues as elsewhere described.

Local anesthesia by the free infiltration of weak solutions of procain and adrenalin restores body fluid, raises the blood-pressure, and is the safest anesthetic in shock.

For *general anesthesia* during shock, nitrous oxid-oxygen, or ethylene-oxygen with at least 25 per cent. of oxygen, or local anesthesia should be selected. Cyanosis from anesthesia is especially dangerous during shock.

Treatment of Shock.—1. *Arrest Hemorrhage.*—Bleeding produces shock, and shock sensitizes the organism to hemorrhage, so a relatively slight hemorrhage may be fatal and should be prevented. The tourniquet is to be avoided as far as possible and only used as a temporary measure (a) where the bleeding cannot immediately be arrested by ligature, suture, or packing in the wound; (b) where the part has been completely devitalized, the tourniquet being applied close to the traumatized area, and left on until after the amputation to limit the absorption of wound products and thus prevent secondary shock.

2. *Restore Body Temperature.*—The injured person should be protected from cold or exposure. Blankets, guarded hot-water bottles, a tent or canopy containing superheated air from electric lights or other source should be used.

3. *Relieve Pain and Restlessness.* The shocked patient usually suffers little pain, but may be very restless, particularly if there has been hemorrhage. This should be controlled by moderate doses of morphin. The morphin does not reduce the alkali reserve, but reduces the oxygen interchange in the tissues, sparing that in the blood. Large doses, further depressing the already damaged centers, should be avoided.

4. *Raise Blood-pressure.*—In the early stages of shock, with vasocontraction, the posture may be unimportant; in the later stages, of vasorelaxation, the lower part of the body should be raised. Drugs, such as pituitrin, adrenalin, strychnin, and camphor are, as a rule, valueless. To restore blood-volume: (a) Liquids by rectum and by mouth should be given as freely as possible. Vomiting, abdominal injury, or relaxation of the sphincter may prevent the introduction of fluids in these ways. (b) A dependable method of supplying liquid to the body is by continuous gravity hypodermoclysis, through two non-corrosive needles introduced in the subcutaneous tissues below the clavicles or elsewhere. Salt solution given intravenously has only a temporary effect upon the blood-pressure, and should not be used in large quantities. Three hundred to 500 c.c. of decinormal saline solution, containing 5 to 25 per cent. of glucose, may very slowly be given intravenously. (c) *Gum-salt solution* (Bayliss) has the same viscosity as whole blood, tending to remain in the blood-vessels and to maintain the blood-pressure. This consists of 6 to 7 per cent. of *gum acacia* in a 0.9 per cent. sodium-chlorid solution. The purest pearls of acacia are soaked in freshly distilled water in a refrigerator for one day, then quickly dissolved over a hot-water bath, filtered through coarse filter-paper, and the sodium chlorid added. The bulk is made up by adding distilled water, and the solution sterilized. G. G. Ward adds 20 per cent. of glucose and largely eliminates reactions by giving not over 4 c.c. per minute at a temperature of 104° F. Gum-salt solution will restore the blood-pressure after a withdrawal of 40 per cent. of the blood-volume, but is valuable only when used early. In the later stages of shock the capillaries become permeable even to colloids, so that transfused blood or gum-solution is not retained in the blood-vessels. In the wounded the blood-volume is very slowly restored; less than two-thirds of the normal bulk of blood may be present even after five or six days. (d) *Blood-transfusion* is valuable to restore the blood-volume and the blood-pressure, but, like gum-salt solution, it may be valueless when given late. Transfusion is preferable when hemorrhage has been a large factor in producing the shock. Injured nerve-cells require better blood

for restoration than normal cells do for mere maintenance. Rapid transfusion, consuming only five or ten minutes, may cause a fall in blood-pressure, which is absent when forty to seventy-five minutes are taken for the transfusion. If the blood examination after intravenous injection shows a continued concentration, the condition is unfavorable; if, as shown by the repeated hemoglobin estimations, there is evidence of dilution of the blood, the desired effect is being produced.

To avoid further shock or unfavorable reaction, the introduction of blood or other fluid into a vessel should be made very slowly, and repeated small blood transfusions, 300 to 700 c.c., are preferable to a single large transfusion of typed blood.

5. *Operation.*—In *primary shock* operation should be done at once; in *secondary shock* delay should be practised. Santy found that, in operations done during shock in from one to three hours after the injury, the mortality was 10 to 12 per cent.; after three to six hours, the mortality was from 36 to 41 per cent.; after eight to ten hours, the mortality was 75 per cent. Larry said the crushing wounds of the extremities are to be operated upon at once, for this gives the only hope. In secondary shock and, as a rule, in profound primary shock operation should be delayed until reaction occurs. Meanwhile an attempt is made to suppress absorption from the traumatized area and to produce reaction. If there is a complete crush of the part, a tourniquet should be applied, and not removed until the amputation is complete. If an amputation is not necessary the extensively devitalized tissues may be débrided. In operating it is very important to supply heat, prevent exposure, hemorrhage, and extensive manipulation. The operation should be brief and radical.

Prophylaxis Against Operative Shock.—Shock may be reduced or prevented by: (a) Sharp, clean-cut incisions. (b) Gentle handling of tissues. Crushing, traction, irrigation, sponging, and manipulation should be reduced to a minimum. (c) Protection of viscera from exposure. (d) Prevention of hemorrhage. (e) Rapid operating. (f) Avoidance of mental excitation. (g) Nerve-blocking—sensitive tissues or large nerve-trunks should be anesthetized by injections of novocain through a fine needle before division.

Anesthesia.—Although anesthesia prevents operative shock, it intensifies a pre-existing shock. Profound, prolonged anesthesia, or anesthesia with cyanosis, induces shock. The least shock occurs with local anesthesia; the greatest with chloroform. An ample supply of oxygen to the lungs is very important in the prevention of shock.

In shock consider:

1. *Rest, warmth, quiet.*
2. *Nourishment*—introduction of warm liquids by stomach, rectum, under skin, or intravenously.
3. *Transfusion*—(a) autotransfusion, (b) homologous by donor.
4. *Position*—head low.
5. *Opiates*—to be given with great care.
6. *Hemorrhage*, internal.
7. *Operation*—to be delayed, if possible, until reaction occurs.
8. *Blood-pressure:* If the systolic pressure is below 60, the patient will rarely recover without treatment. If below 50, the patient usually will die despite treatment. The tissues are supplied with blood by the diastolic pressure.

CHAPTER IX

COMA AND DELIRIUM

Coma is complete loss of consciousness.

Etiology (A. E. I. O. U.—Alcohol, Epilepsy, Injury, Opium, Uremia).—1. *Alcohol:* The coma is rarely complete, the patient may be aroused by shaking or shouting; respirations are deep; snoring not stertorous; the pupils moderately dilated and equal; temperature subnormal; pulse full, slightly increased in rate; alcoholic odor to breath and gastric contents.

2. *Epilepsy* (*Status Epilepticus, Postepileptic Coma*).—A history of "fits," a duration of one hour or less, and scars about back of head suggest an epileptic coma. Convulsions preceding the coma, a bitten tongue, froth in the mouth, and urinary incontinence confirm the diagnosis.

3. *Injury and Cerebral Disease.*—(a) *Meningeal Hemorrhage* (intra- or extradural): History of injury followed by latent period, and then the gradual onset of coma. Local evidence of injury with temperature normal, or later elevated; pupils irregular; pulse slow, full, becoming weak and rapid; respirations stertorous, becoming Cheyne-Stokes in type; evidence of paralysis, papilledema, and bloody spinal fluid with increased intradural pressure. (b) *Cerebral Hemorrhage or Embolism:* Sudden onset with deep coma, hemiplegia, pupils dilated (larger on affected side), temperature normal or elevated, in a patient with evidence of arteriosclerosis, or valvular heart disease with vegetations. In pontile hemorrhage there is bilateral paralysis, contracted pupils, pyrexia, or perhaps crossed paralysis. (c) *Meningitis, Encephalitis:* Gradual onset with preceding convulsions and alterations in spinal fluid. Intracranial tumor or abscess give localizing signs, a preceding chronic headache, projectile vomiting, choked disk, and monoplegia. (d) *Pachymeningitis Externa Hemorrhagica:* In elderly men, with progressive mental deterioration, *dementia paralytica.*

4. *Narcotics.*—Include chloral, chloroform, veronal, carbolic acid, oxalic acid, carbon monoxid, chloretone. Opium and morphin produce contracted pupils, slowed respirations, moist skin, with normal temperature and reflexes. Chloral, paraldehyd, and chloretone, a coma resembling that from alcohol. In *carbon-monoxid poisoning, mephitism*, as from the exhaust gas from an automobile, the color of the blood and skin is cherry red.

5. *Uremia, Cholemia, and Associated Conditions.*—Usually there is a history of previous uremia, acidosis, cholemia, eclampsia, acute yellow atrophy, Banti's disease, or other disease of the liver or kidneys. The patient should be examined for diabetes, changes in the urine and blood, high blood-pressure, sclerotic arteries, and edema, and the history studied for preceding headache, vomiting, and convulsions. In diabetes there is air-hunger, acetone odor to breath, glycosuria, ketonuria, and high blood-sugar.

6. *Lead-encephalopathy* is associated with mania, delirium, coma, blue line

on gums, thickened arteries, anemia, cachexia, constipation, previous colic or wrist-drop; no paralysis of brachioradialis. Lead is present in urine and feces.

7. *Hysteria, Neurosis.*—The color, pulse, temperature, and respiration are normal. There is winking or contraction of eyelids, with resistance to raising lids.

8. *Hemorrhage, Shock, Collapse.*—Pallor; rapid, weak pulse; history and associated symptoms.

9. *Malignant Malaria.*—Preceding history with protozoa in the blood.

10. *Sunstroke, Hyperpyrexia.*—Incontinence of feces; history of exposure to heat.

11. *Extreme Cold or Heat Exhaustion.*—Depression of bodily functions and temperature, with the history of exposure.

12. *Internal hydrocephalus* from obstruction by tumor or inflammation is a cause of coma.

Examination.—Conditions to be noted in the *examination of the patient:*

1. *Skin:* Pallid, suffused, cyanotic, cherry red, blood- or acid-stained; evidence of hypodermic injections, edema, extravasation, contusion, or laceration; hemorrhage or cerebrospinal fluid from the ear, nose, or mouth. Injury to head or other part of the body.

2. *Respirations:* Rapid, slow, stertorous, Cheyne-Stokes.

3. *Vascular System:* Normal, slow, full, rapid, or weak pulse; evidence of arteriosclerosis, arterial thickening from lead-poisoning; enlargement or displacement of heart, special murmurs.

4. *Eyes:* (a) *Pupils* normal, reactive, contracted, dilated, unequal. (b) *Fundus:* papilledema, choked disk, Gunn's vessels (arteriosclerosis), albuminuric or diabetic retinitis. Nystagmus, ocular palsy, and conjunctival ecchymosis.

5. *Paralysis:* Flaccidity or lack of tone in arm or leg, puffing of paralyzed cheek, conjugate deviation of eyes and head; unequal abdominal reflexes (especially valuable); the tendon, cremasteric, Babinski, Kernig reaction.

6. *Breath:* Odor of alcohol, acetone, laudanum, phenol.

7. *Temperature* by rectum; normal, subnormal, or raised.

8. *Urine:* Sugar, albumin, urea percentage; leukocytes, erythrocytes, and casts.

9. *Blood Examination:* Urea, creatinin, sugar, plasma carbon-dioxid combining power, chlorids; plasmodia or other parasites; Wassermann reaction.

10. *Lumbar puncture:* cells, increased pressure.

11. *Brain and meninges:* Tumors, hemorrhage, internal hydrocephalus, cell count, type of cells, Wassermann.

12. *Gastric contents* may show poison, blood, or alcohol.

13. *Heart Examination:* Evidence of vegetative endocarditis (cerebral embolism), cardiorenal disease (uremia).

Traumatic Delirium.—After injury or operation there is usually an abrupt change in customary habits, with confinement to bed, curtailment of exercise, reduction of elimination, and change in diet. These factors, with dehydration, partial starvation, mental strain, exposure, irritation, toxemia from anesthetics and other sedatives, and perhaps the withholding of alcohol, morphin, cocain, or other drug to which the patient is accustomed, favor the development of delirium. The delirium may be:

1. **Direct traumatic delirium** from: (a) the *absorption of toxic substances* from crushed and devitalized parts, in which case it should be treated by the suppression of absorption from the wounded area, by débridement or amputation. (b) *Cerebral injury*, as in cerebral contusion, cerebral irritation, or serous meningitis. (c) *Bacterial infection* from the wound or injured part; should be treated by evacuation, disinfection, and drainage. (d) *Drug delirium* from the absorption of iodoform, phenol, picric acid, mercurochrome, or other toxic substance used; to be treated by removal, neutralization, and elimination of the drug.

2. **Indirect traumatic delirium** occurs especially in those with a narrow metabolic balance from age, disease, or dissipation. (a) *Alcoholic Delirium (Delirium Tremens)*: *Anstie's limit*—$1\frac{1}{2}$ ounces of absolute alcohol, or 3 ounces of whisky daily, is the limit in moderation in drinking. (b) *Narcotic delirium, drug-habit delirium*, from morphin, cocain, heroin, chloral; to be treated, previous to the development of delirium or mania, by the gradual withdrawal of the drug, and the use of an excess of liquids, saline purgation, overfeeding, and the administration of hyoscin and bromids. The continuance of the drug after delirium begins is useless. (c) *Delirium from Defective Metabolism* occurs from chronic degenerative disease of the liver, Banti's disease, nephritis, from degeneration of other parenchymatous organs, or from diabetes. It is characterized by mental depression or excitation, insomnia, restlessness, diarrhea, vomiting, prostration, coma and, frequently, death. The patient often promptly recovers, if treated out of bed as an ambulant patient with light massage, warm baths, alcohol rubs, other eliminative measures, prevention of dehydration, appropriate liquid diet and, if necessary, insulin.

3. **Delirium of Pneumonia.**—*Basal* or *hypostatic pneumonia* is common in elderly or debilitated patients after injury or operation, and is a cause of delirium which is frequently fatal. It is a postoperative complication that may give few symptoms and may easily be overlooked in the aged. It should be treated by frequent changes in position (preferably the Fowler position), by digitalis and other cardiac stimulants, and by eliminative measures.

Diagnosis.—In all cases of delirium following operation or injury the wound should carefully be inspected for possible infection. Pressure sores, Volkmann's contracture, pneumonia, uremia, and cholemia should carefully be excluded. An unrecognized necrosis or infection, under a plaster-of-Paris dressing or splint for fracture, is frequently responsible for delirium.

Delirium may be (1) *wild* and *active*, requiring restraint, or (2) *low, muttering (typhoid delirium)*. It is to be remembered that many drugs, as belladonna, cannabis indica, ether, chloroform, hyoscyamus, morphin, salicylates, or allonal, may cause secondary delirium.

Delirium Tremens (Mania à potu).—Etiology.—*Prolonged addiction* to the stronger alcoholics, such as whisky, brandy, gin, or rum. *Male sex*, between the ages of forty and sixty years. *Exciting causes:* Confinement to bed by operation which may be of a minor type, as upon the eyes; or for a fracture or other injury.

Symptoms.—1. *Prodromata* appear in twenty-four hours, with fine tremor of hands and tongue, irritability, restlessness, insomnia. The patient mumbles

and talks to himself, and picks or pulls at the bed-clothes or dressings. This is followed, usually within twenty-four hours, by hallucinations (recognized as imaginary) and bad dreams, with depression and restlessness which may persist for several days, to be followed by delirium or recovery.

2. *Delirious stage* is characterized by a noisy, busy, active delirium, with loss of orientation as to time and place; hallucinations of sight, with visions of rats, snakes, loathsome forms, with terror (*the horrors*), animals creeping over the body, or about the room. Hallucination as to sounds are less prominent. There is insomnia, tremor, progressive weakness, the tongue is thickly coated, the pulse rapid, the temperature 100° to 102° F.; fighting, cursing, striking, with loss of sense of pain—the patient walks upon his fractured leg, and traumatizes a crushed part or amputation stump. After a continuous delirium for two to five days the mind clears, and the patient, weak and exhausted, has no recollection of his hallucinations. Insomnia may continue, and the symptoms of a wet brain follow the delirium.

Prognosis.—The mortality is high from: (1) *Pneumonia*, which often develops; (2) *exhaustion* and cardiac failure; (3) *wound complications* induced by the constant movement; or, occasionally, (4) *suicide*.

Treatment 1. *Prophylactic:* For those addicted, alcoholic drinks should not be withdrawn during the first week after injury; rigid confinement to bed should be avoided, and elimination should be aided by laxatives, diuretics, baths, and frequent changes in position.

2. *Stage of Onset:* With the development of tremor, restlessness, insomnia, tendency to excitement or depression, the patient, if possible, should be moved out of bed into a chair, or permitted to go about the room. Careful examination should be made for hypostatic or croupous pneumonia. Elimination should be free and continued by the use of saline laxatives, diuretics, and prolonged hot baths; chloral (0.6 to 1 gm.), bromids (1.3 to 4 gm.), paraldehyd (4 to 8 c.c.), chloretone (0.6 gm.), apomorphin (0.0026 to 0.0043 gm.), or other sedatives are of some value.

3. *Stage of Delirium:* For the delirium, prolonged hot baths, if possible, or hot packs, chloral, bromids, morphin, scopolamin, and apomorphin (with great care) are sedative. For cardiac weakness, digitalis, strophanthus, ammonia, and camphorated oil are used. If hypostatic congestion or pneumonia develops, large doses of quinin should be given. Cool sponging may be desirable if there is high temperature. If nourishment cannot be continued by mouth or rectum or by a Jutte tube through the nose, intravenous injections of 20 per cent. glucose in saline should be used. Alcohol is valueless after the delirium begins.

4. *During convalescence*, capsicum, tonics, and heavy feeding are desirable.

Sequela: *Alcoholic serous meningitis (wet brain)*, characterized by an excess of serous fluid in the meninges, occurs in chronic alcoholism following delirium tremens. There is a noisy delirium changing to a low and muttering type, with the patient prostrated and pallid, lying on his back with his arms extended toward the ceiling. This may be followed by coma, with rigidity of the muscles of the neck and back.

Mortality, 50 per cent., death being from cardiac failure and pneumonia.

Treatment.—Hypertonic salt solution by rectum or intravenously. Magne-

sium sulphate and laxatives by mouth and rectum. Adequate liquid nourishment. In all cases the wound should be watched, protected, splinted, and, if infection develops, freely opened and drained. An unrecognized infection under a case or bandage may be responsible for the patient's mental change.

Diabetic Coma.—The diabetic is subject not only to *hyperglycemia*, but when starved, or when the carbohydrate intake is greatly restricted, to *ketosis*, *acidosis*, and *coma* with acetonuria from the faulty utilization of fat. *Uremia*, with increased blood-urea and non-protein nitrogen, is not infrequent from associated renal damage. The normal (25 to 35 mg. per 100 c.c.) for non-protein nitrogen and the normal (15 to 25 mg. per 100 c.c.) for urea are exceeded; the normal plasma carbon-dioxid combining power (55 to 65 volumes per cent.) reduced. The suprarenal, thyroid, pituitary, and pancreas are concerned in the metabolism of carbohydrates. Adrenalin converts the glycogen of the liver into sugar, or causes increase in the amount of glycogen in the liver through mobilization of the sugar in the muscles.

Sugar tolerance also is much reduced in exophthalmic goiter. Obesity, heredity, age, infection, and nervous strain are important factors in diabetes.

Hypoglycemia from the administration of insulin causes serious symptoms, including sweating, apprehension, flushing, pallor, constriction around the waist, coldness, cold extremities, collapse, convulsions and delirium, which appear in from two to twelve hours after the injection of insulin. These symptoms are to be combated by the administration of orange juice, glucose, or sugar.

Generalized arteriosclerosis is also common in diabetes, with a lowered resistance of the extremities to injury, and a tendency to gangrene; for this reason a local anesthetic should be used in the diabetic only for operations about the head, neck, and trunk. Spinal anesthesia is preferred for operations on the lower extremities, and caudal or sacral anesthesia for operations about the pelvis. For the arm, a brachial plexus or nerve-block may be made. Ether and especially chloroform should be avoided in diabetes—nitrous oxid is harmful, especially when used to the point of cyanosis. Immediately before the operation the patient should not be starved or put on a rigid diet for fear of ketosis. Before the operation 50 gm. of glucose is to be given by mouth, rectum, or intravenously, guarded by an injection of 1 unit of insulin for every $2\frac{1}{2}$ gm. of glucose administered. If coma is present, or develops after the operation, the patient should be studied for ketosis as shown by acetonuria and other evidences. For hypoglycemia and ketosis (convulsions with coma), 100 units of insulin should be given immediately with 100 gm. of glucose in 10 to 20 per cent. solution intravenously (MacLeod). Forty to sixty units of insulin and 30 gm. of glucose are then given every four hours, guided by blood and urinary tests. In hypoglycemia, not only should carbohydrate be given immediately, but also 1 c.c. of a 1 : 1000 epinephrin solution or 1 c.c. of pituitrin, intramuscularly, to mobilize any glycogen stored in the liver or muscles.

If time is not an element before operating upon a diabetic, the patient should be placed upon a standard basal-requirement diet, and adjustments made until a satisfactory diet without hyperglycemia is obtained.

Operative treatment is required in at least 11 per cent. of diabetics (Joslin).

The *mortality* from operations in diabetes has been reduced one-half or more by the use of diet and insulin, guided by laboratory studies. The diagnosis is more serious with a high renal threshold. With blood-sugar higher than 0.35 per cent., or a carbon-dioxid combining power of plasma less than 40 volumes per cent. at the time of operation, the prognosis is unfavorable. Sodium bicarbonate is dangerous, splitting off the ketone substances with toxic effect upon the centers, and should not be given. Alkalies are particularly dangerous when the kidneys are diseased.

Diabetic and non-diabetic *acidosis* are both successfully treated with insulin. Before operation the urine should be acid and free from sugar. A diet of egg-white, oatmeal gruel, and orange juice is of value.

Before operating upon a diabetic patient it is desirable that the patient be on an adjusted *basal-metabolic diet*, that the urine be sugar free, and that the hyperglycemia be overcome, if necessary, by the use of insulin. To prevent ketosis the patient should have a sufficient supply of carbohydrate. It is desirable to provide a diet that will contain about one and one-half times as much fatty acid as glucose, because such a diet can be formed without an undue amount of carbohydrate food, yet with sufficient amount of fat to give it a high caloric value without inviting acidosis. The ketogenic-antiketogenic ratio is the amount of ketone formers in the diet in relation to the total glucose which can be obtained in process of digestion of the food. Forty-six per cent. of protein and 90 per cent. of fat form fatty acids, which subsequently break down to form acetone or ketone bodies. Glucose (the antiketogenic factor) is derived from carbohydrate, protein, and fat. All of the carbohydrate, 58 per cent. of the protein, and 10 per cent. of the fat are changed to glucose in the body.

Basal Caloric Requirement (Woodyat).—In the following formulas G equals total glucose; C, carbohydrate; P, protein; F, fat. The total calories divided by 17 equals the glucose requirement.

2 times weight in kg., divided by 3, equals P.

8 G divided by 10, minus P divided by 2, equals C.

2 C plus P divided by 2, equals F.

To this diet 10 per cent. additional carbohydrate should be added for energy expended. If, upon such a basal diet, the glucosuria does not disappear in four or five days, or if it reappears before the desired quantities are reached, then insulin is used. Three meals a day should be eaten. Unless the renal threshold is low, sugar appears in the urine when the blood-sugar exceeds the level of 180 mg. to 100 c.c. Insulin is given before meals for two or three days in quantities sufficient to prevent glycosuria or hyperglycemia.

Hypoglycemia is more dangerous to life than hyperglycemia. Usually it occurs suddenly two to four hours after an excess of insulin has been given and, if not promptly relieved by giving orange juice, sugar, or other carbohydrate, may be fatal. The symptoms are:

(1) Sudden and pronounced hunger, sudden weakness or fatigue, a peculiar restlessness or nervousness, an inward trembling or shake, pallor or flushing of the face, dilated pupils, increased pulse-rate; important especially in children. (2) Sweating which is most characteristic, tremor and muscular incoördination, anxiety, fear, apprehension, excitement, emotional disturbance, vertigo, diplopia (3) Aphasia, disorientation, delirium, confusion. (4) Convulsions, collapse, low blood-pressure, low body temperature, unconsciousness. (5) Death.

The injection of insulin and feeding should be closely associated. If food is not absorbed (through vomiting, diarrhea, or other cause) it may be necessary to give glucose or dextrose intravenously.

The dose of insulin should be about 2 units below that producing a mild reaction.

Diabetic acidosis is characterized by restlessness, drowsiness, slight difficulty in breathing, an acetone odor to the breath, and acetone and aceto-acetic acid in the urine. Vomiting is common. These symptoms are followed by coma, air-hunger, dehydration, dry tongue, soft eyeballs, stupor, or complete unconsciousness with hyperglycemia. The coma should be differentiated from that due to pneumonia, nephritis, injury, or infection.

Forty units of insulin should be immediately injected subcutaneously, and 20 to 40 units given every three or four hours until the urine is sugar free, when glucose (equaling in grams the number of units injected) is given by mouth, rectum, or intravenously, guided by the amount of blood-sugar and by the carbon-dioxid combining power of the blood-plasma. Rest, quiet, warmth, and gastric lavage, excess of fluid, enemas, cardiac stimulants, including digitalis and caffein, are also of value. Sodium bicarbonate may be harmful.

Infection lowers the tolerance of the diabetic patient for glucose, and is most serious in severe forms of diabetes. The dose of insulin should, therefore, be increased to the point of overcoming acidosis and preventing glycosuria. A sufficient supply of carbohydrate in the form of orange juice, milk, white bread, cereals, or glucose should be given.

Diabetic Gangrene.—With poor circulation, early amputation is desirable. If the circulation is fair, conservation, with warm baths, light-baths, gentle passive movement, may be tried. The diet should contain a higher percentage of carbohydrates carefully balanced by as much insulin as is required. The insulin usually is reduced as the wound heals.

Elective operations should be postponed until the patient is adjusted to a basal diet with, if necessary, sufficient insulin to obtain a nearly normal amount of blood-sugar and a flow of glycogen to the tissues at the time of operation. It is often desirable to give fluids and glucose by mouth, rectum, or vein before or after the operation.

Non-diabetic acidosis occurs in starvation, prolonged vomiting, intestinal obstruction, and in postoperative surgical conditions, with acidosis or ketosis.

Treatment is by the intravenous administration of a 20 per cent. solution of glucose, to which insulin is added in the proportion of 1 unit for each 2 gm. The injection is given slowly (at the rate of 10 c.c. per minute) at, or slightly above, the body temperature. One hundred to 200 c.c. are given to infants, and 800 to 1000 c.c. to adults.

CHAPTER X

INFECTION AND DISINFECTION

INFECTION

The harmful invasion of human tissues by bacteria produces results that vary with (1) the individual patient and his resistance; (2) the bacterium, and its virulence and number, and (3) the treatment used. A micro-organism may be modified in virulence by previous environment and bacterial association. For example, the streptococcus may behave in the body as a harmless saprophyte, be a producer of a local inflammation or of a fatal bacteremia. By pathogenic activities in the animal body the micro-organism acquires virulence.

Special Types of Infection —1. *Pyogenic infection*, characterized by the formation of pus, as in infection by the staphylococcus, streptococcus, Bacillus pyocyaneus, and colon bacillus.

2. *Toxic infection* is chiefly expressed by a general toxemia, as in diphtheria and tetanus.

3. *Serohemorrhagic Infection:* There is an effusion of blood-stained serum, as in anthrax.

4. *Necrotizing* or *gangrenous infection* is shown by extensive death of tissue, as in noma and wound diphtheria.

5. *Gas infections* are associated with the formation of gas in the tissues, as in malignant edema or infections by Bacillus aërogenes capsulatus or the colon bacillus.

6. *Granulomatous infections*, or *proliferative infections*, are specific chronic inflammations with the formation of granulation tissue, as in actinomycosis, tuberculosis, syphilis, rhinoscleroma, sporotrichosis.

Immunity to infection is influenced by race, age, sex (*natural immunity*); previous disease, inoculation or serum injection (*acquired immunity*); associated disease, and other factors. The *susceptibility* of the tissues to infection is increased by operative or other trauma.

Infection is characterized by: (a) *Inoculation*, the entrance of bacteria into the tissues. (b) *Incubation*, a period of bacterial multiplication and invasion without symptoms. (c) *Onset of prodromal symptoms*, locally shown by itching, formication, throbbing, pain, redness, increase of secretion; generally indicated by rise in temperature, increased pulse and respiratory rate, leukocytosis, stimulation or depression of the nervous system and other symptoms. (d) *Fastigium*, or *period of active disease*, shown locally by redness, swelling, pain, exudation, increased secretion or suppuration, and generally by fever and its associated phenomena.

The *infection may terminate* by crisis or lysis, by resolution, by evacuation of the inflammatory products, by spread of the infection locally or generally, with or without fatal consequences.

Treatment of Infection.—1. The *period of inoculation* and *incubation* is the period for the prevention of the disease by: (a) Local disinfection; (b) excision or destruction of the invaded tissues; (c) use of appropriate vaccines. For example, the application of 33 per cent. calomel ointment immediately after inoculation usually prevents the development of syphilis. The instillation of a 2 per cent. solution of nitrate of silver in the conjunctival sac prevents gonorrheal ophthalmia. Pyogenic infection of the skin may be prevented by yellow oxid of mercury or other antiseptic ointment. In the World War the incidence of tetanus was greatly reduced by excision or débridement of the wound, and eliminated by early prophylactic injections of tetanus antitoxin.

2. *The Period of Prodromal Symptoms.*—Local disinfection by excision and destruction of the invaded tissue is less effective at this period, and may, if the micro-organisms have invaded the lymphatics, be very harmful, by breaking down natural barriers which have been erected to limit the spread of the infection. Thus, local manipulation, curettage, incisions, and excisions frequently have converted a partially localized streptococcal infection into an intense bacteremia, or have caused an anthrax carbuncle to become a fatal anthrax septicemia. In this stage antitoxin should be used in much larger doses. Local rest and protection from traumatism and general rest in bed are most important in aiding the localization of the infection. In severe *infection of the hand*, for example, the part is surrounded by a voluminous protective dressing, the hand and arm placed on a splint, and the patient in bed. In *peritonitis* or *enteritis* local rest is obtained by withholding all medicine, liquid, or food by mouth, and by keeping the patient quiet in bed.

3. *The Period of Fastigium.*—In this period local and general rest is continued. Antitoxins are much less effective, and an enormous increase in dosage may be required. If the disease is prolonged or chronic, vaccines may have a value in stimulating increased resistance to the infection. Operation often is required for the evacuation of inflammatory collections, to remove necrotic tissue, or to correct obstructive conditions. It is important to maintain the nutrition and resistance of the patient, and to combat acidosis or alkalinosis, deficient glandular action, deficient elimination, dehydration, and the like. Hence, nourishment, vitamins, transfusions, subcutaneous infusions, specific chemicals and antiseptics, glandular extractives, and other measures are used in this stage.

4. *After the crisis* or *lysis*, and recovery from infection, much *after-treatment* may be necessary to bring the patient to a normal condition. Inflammatory exudates and adhesions are to be removed, crippled parts restored or trained to use, and organs that have been damaged by disease properly cared for. Plastic and orthopedic operations are often desirable; diet, massage, baths, special forms of exercise, ultraviolet rays, Roentgen rays, diathermy, and other measures are valuable aids in the restoration of function.

Infection through the Blood-stream.—The older concept was that bacteria rarely entered the blood except in disease. In *septicemia* the bacteria formerly were supposed to enter, multiply, and have their chief activities in the circulating blood, while in *pyemia*, pyogenic bacteria producing secondary abscesses were transmitted through the blood from one part of the body to

another, without multiplying or being active in the blood itself. It is now known that bacteria are constantly entering the blood in healthy persons, but are usually rapidly filtered out and destroyed by various organs, cells, or fluids of the body.

Septicemia or *bacteremia* is a condition in which pathogenic micro-organisms, for a considerable time, occur in large numbers in the circulating blood, and by it are passed to various parts of the body. If secondary abscesses are produced, the term *pyemia* is applied.

Bacteria are removed from the blood-stream chiefly in the capillary meshwork of the spleen, liver, and bone-marrow. The cells of the reticulo-endothelial system have pronounced phagocytic power. Bactericidal substances are also formed, and enter the blood, the process of bacterial destruction being especially active in the organs where the blood-current is slowed. In bacteremia the micro-organisms have a *focus of infection* from which they continuously or repeatedly enter the blood. As a result, the spleen and other filtering organs often enlarge and develop lesions. By eliminating the source of bacterial supply, provided the defensive mechanism of the body has not broken down, bacteria rapidly disappear from the blood. As a rule, bacteria remain for too short a time in the blood-stream to be effectively destroyed by agents that act only within the blood.

Treatment.—Attempts have been made to destroy bacteria circulating in the blood by the use of chemical antiseptics. Inspired by the efficacy of Ehrlich's salvarsan in syphilis, *quinin* or *optochin* (which is several times as powerful as quinin), the acridin derivatives, flavin, acriflavin and proflavin, a $\frac{1}{2}$ per cent. solution of hydrochloric acid, gentian-violet and other dyes, mercurochrome, formalin, and other antiseptics have been injected into the blood-stream, with the idea of direct blood disinfection. This form of therapy is based on the old concept that the bacteria live and multiply in the blood. In the blood, bacteria are as birds of passage. They live and multiply in the solid tissues where, to be effective, the antiseptic must reach them, without crippling the normal protective mechanism.

Drugs introduced intravenously: (1) May change into potent substances; (2) may stimulate bactericidal action; (3) may be sequestered in certain organs where the bacteria are destroyed.

The dye or drug may be *bacteriostatic*, rather than *germicidal*, effecting inhibition instead of actual bacterial destruction. It may reduce the activity of toxins or be antitoxic, as shown by Behring with methyl-violet, safranin, and malachite green.

Mercurochrome-220 soluble, dibrom-oxymercury-fluorescein, containing about 26 per cent. of mercury, has chiefly been used against blood-stream infections by streptococci. Its effects may be due to a photodynamic action. It may produce very serious toxic effects upon the kidneys and other organs, and it loses its germicidal power when dissolved in serum. Lauded by Young for certain blood-stream infections, its value is questioned by other observers.

Gentian-violet is used intravenously in doses of 5 mg. per kilogram of body weight, 2 to 3 mg. per kilogram being used in children and very old people. It is dissolved in sterile water or sterile physiologic salt solution, and used in a

0.25 to 1 per cent. solution (0.5 per cent. solution is preferred). It disappears from the blood-stream in one and one-quarter hours. Gentian-violet has especially been used against Gram-positive staphylococci. As with mercurochrome, only a temporary bacteriostatic action with retardation of the infection may be produced.

Hexylresorcinol (caprokol), in doses of 0.15 to 0.6 gm. given three times a day, renders the urine more or less bactericidal. It is more efficient against the Streptococcus antihæmolyticus and Bacillus pyocyaneus than against the Bacillus coli. For urinary infections the course of treatment should be uninterrupted and prolonged. Urinary infection by the Bacillus coli and related bacteria requires sixty to ninety days' continuous treatment. It is useful in infections of the kidney, renal and visceral tuberculosis; infections of the prostate, and seminal glands. It is effective in about 21 per cent. of the patients, especially against infection by the colon bacillus, staphylococcus, or mixed micro-organisms. In glycerin solution it seems to be a valuable, non-irritating, but expensive surface disinfectant.

Summary.—In Acute Sepsis Consider: 1. *Dilution of toxins* by hypodermoclysis (continuous or intermittent), transfusion (especially from an immune person), proctoclysis.

2. *Elimination* by hot packs, electric-light baths, warm alcohol sponges. Avoid opiates as a rule.

3. *Alkalinization* by sodium bicarbonate, sodium citrate.

4. *Drainage*, aided by heat, moisture, dependency, capillary attraction.

5. *Antidotal measures*—serums and vaccines, calcium lactate or chlorid intravenously, extracts of ductless glands.

6. *Support of patient* by easily assimilable food, iron, mineral acids, digitalis.

7. *Rest*, general and local. Avoid manipulating, squeezing, milking, palpating, or massaging the wound or infected area.

DISINFECTION

Natural immunity from infection arises from the *inherent ability* of the body to exclude, inhibit the growth of, or destroy micro-organisms. The natural defenses are often insufficient, and *artificial measures* are then necessary. These include means to prevent infection by:

1. *Asepsis:* The exclusion of living pathogenic organisms.

2. *Antisepsis (Listerism):* The inhibition of the activities of pathogenic organisms, without necessarily destroying the micro-organisms.

3. *Disinfection:* The absolute destruction of pathogenic organisms, insuring *sterility*. An object may be *surgically sterile*, and yet contain the spores of non-pathogenic yeasts and molds, or various non-pathogenic bacteria. Surgical sterility is, therefore, not absolute sterility.

4. *Artificial immunity:* The resistance of the body produced by the introduction of vaccines, serums, or other substances.

An *antiseptic* is a medium which prevents the growth and activity of pathogenic organisms; a *germicide*, one that destroys pathogenic micro-organisms; a *bactericide*, one destroying bacteria.

Sterilization is the destruction of agents capable of causing infection. A

substance rendered incapable of producing infection is said to be *aseptic* or *sterile*. An *antiseptic* inhibits the spread of infection while it is present, a *disinfectant* precludes the possibility of infection. A temperature of 55° C. (131° F.), applied for ten minutes to anthrax bacilli free from spores, is disinfectant, as it so reduces the virulence of the bacteria that they no longer are able to excite disease, yet the bacilli may grow as freely as they did before the heat was applied. Such an exposure is *bacteriostatic*, but not *bactericidal*. The laboratory bactericidal standards usually express conditions far in excess of the requirements of the surgeon, so they may safely be adopted.

The *efficiency of disinfectants* in general, and of special germicides, varies with the parasite, the character of the associated material, the degree in which heat and moisture are present, and the thoroughness and directness of the application. As a rule, non-sporogenous organisms are much more readily killed than those that contain spores. The presence of moisture increases the effectiveness of heat, and the absence of albuminous, fatty, or waxy material facilitates the action of most chemical disinfectants.

Disinfection is produced by: (1) *Chemical agents*, chemical disinfection. (2) *Heat*, thermal disinfection. (3) *Mechanical dilution and removal*, mechanical disinfection. (4) *Light, Roentgen rays, electricity*, or other agents.

Chemical Disinfection.—Watery solutions are, as a rule, most efficient; alcoholic and oily solutions, least capable of disinfecting. The addition of mineral acids increases the activity of a number of chemicals, while solutions of soap increase the efficiency of some and decrease that of others. The penetrative or solvent action of a disinfectant may have an important influence upon the results obtained. Upon greasy skins watery solutions may entirely fail, although effective if the fat first be removed. Mercuric chlorid, which under favorable experimental conditions is an energetic germicide, coagulates albumin; hence is not to be depended upon as disinfectant of solutions containing albumin. In fecal material, mercurial disinfectants may be transformed into inert sulphids or albuminoids. No single practical disinfectant of universal application is known.

Biologic disinfectants are those that while circulating in the living body destroy bacteria or other organized agents.

Thermal Sterilization.—In the application of heat to produce sterilization, dry hot air, baking, boiling, or steaming may be employed. At equal temperatures, moist streaming steam is the most efficient, hot air the least. Each method, however, has special advantages. Some articles are most conveniently disinfected by baking; others cannot be baked, but may be boiled or steamed. Micro-organisms show great variation in their resistance to heat.

Hot Air.—Air must be heated to a temperature about one-third greater than that of steam to have an equal disinfectant action. Hot air is only adapted to dry surfaces that will withstand high temperatures, such as forms of steel, glass, and earthenware. The temper of surgical instruments may be affected. As hot air has little penetrative action, it should not be used to disinfect closely packed articles, such as towels, gauze, cotton, or bundles of fabric. It has been employed to sterilize dry catgut, and other substances damaged by boiling in water or by steaming.

Hot Water.—Boiling is a very practical means of sterilizing substances not injured by contact with hot water. It enables one to conveniently apply an even, moderately high temperature for any desired length of time. The exact temperature, at which the boiling-point is reached, varies with the atmospheric pressure and with the purity of the water. At the sea-level, pure water boils at a temperature of 100° C. (212° F.) and the boiling-point progressively increases or decreases with changes of pressure. At high altitudes the boiling temperature may fall to 60° C. (140° F.) or lower. By enclosing the water so that it is always under the pressure of the liberated steam, the boiling-point may be raised as shown in the following table:

INFLUENCE OF STEAM-PRESSURE (IN POUNDS) UPON THE BOILING-POINT

Pounds.	Fahrenheit (°).	Centigrade (°).
0	212	100
5	228	109
10	240	115.5
15	251	121.5
20	260	126.5
40	287	141.5

Boiling water (at 100° C.) is an efficient disinfectant, practically sterilizing within ten minutes all substances to which it has free access. It is true that certain spores will withstand such an exposure, but, so far as known, they do not include any disease-producing species. Even the spores of anthrax are killed in four minutes by boiling water, and probably lose their virulence at a much lower temperature. The addition of *sodium bicarbonate*, *borax*, or *lime* (in the proportion of 2 per cent.) may increase the penetrative action, although causing a deposit upon the instruments. *Aluminum is eroded by the presence of alkali.*

By the addition of *ammonium sulphate* or *sodium chlorid* to saturation the boiling-point of water may be raised from 100° to about 127° C., and the presence of these salts enables one to boil, without marked injury, gum-elastic catheters, bougies, and similar articles, damaged by boiling in plain water. Syringes, gloves, and other articles made of rubber of good quality may be repeatedly boiled in water, for brief periods of time, without great injury. Catgut and leather, including syringe- and pump-packings of leather, are gelatinized and destroyed unless previously specially prepared by formalization.

Alcohol boils at a much lower temperature than water and, although it is an unreliable agent, it has been used in surgical practice to sterilize catgut. Far more efficient is the boiling of carefully dehydrated catgut in *cumol*, which boils at a temperature between 133° and 160° C.

Steam Sterilization.—Steam is one of the most dependable and generally useful artificial germicides. Sterilization entails the consumption of energy and, as steam contains a relatively much higher potential of energy (in the form of latent heat) than does boiling water or heated air, it is a much more active sterilizing agent. To convert a given weight of water at the boiling-point into steam, nearly one thousand times as much heat is needed as is required to raise the temperature of water from 211° to 212° F. This great amount of latent heat, stored up in the steam, is liberated upon its condensation. From this it follows that, to obtain the most efficient action of steam, at least a partial

condensation is necessary. Thus, if superheated steam is passed through bundles of fabric, it will be found that the greatest action occurs at the interior of the bundles (where partial condensation takes place) rather than upon the exterior, where the fabrics quickly reach such a high temperature that hardly any condensation can occur. For the same reason, *superheated steam*, which acts at a temperature far above its point of condensation, is relatively much less efficient than *streaming, saturated steam*. *Saturated steam* has a temperature corresponding to the pressure under which it is held, so that the slightest cooling will result in condensation. At the pressure of one atmosphere, for example, saturated steam has a temperature of 100° C., and the point of saturation varies according to the table previously given. *Superheated steam* has a higher temperature than that corresponding to the pressure in which it exists. It does not condense until cooled to the saturation point. It is obtained by heating saturated steam or by adding certain salts (such as *sodium chlorid*) to water, in order to raise the temperature at which the steam will be liberated. Saturated steam has a relatively greater penetrative power and disinfectant action than superheated steam. In condensing, it imparts to surrounding media a temperature above that at which it exists. Where it comes in contact with or enters articles to be disinfected, cooling produces a partial condensation, and the liberated latent heat is transferred to the material. The successive great reductions in volume (resulting from the condensation) attract more and more steam to the area, so it penetrates quickly even large bundles of fabric. For the use of steam at high temperatures, sterilizers capable of withstanding high pressures, and known as *autoclaves* or *steam-pressure sterilizers*, are employed. Any air remaining in such an apparatus greatly interferes with the action of the steam, and may prevent sterilization. Despite the high temperature and pressure of the steam, the contained air serves to insulate the articles from the heat. To insure sterilization, therefore, it is essential that all the air be first expelled, either by permitting the steam to escape for a considerable time before sealing the apparatus, or else by exhausting the chamber two or three times during the process of sterilization. If great care be not taken in this regard, to insure sufficient circulation of the confined steam, the pressure sterilizer is less trustworthy than a simple sterilizer employing streaming steam.

Superheated steam does not moisten paper or fabrics, and for this reason may be used to sterilize objects damaged by water. At the ordinary atmospheric pressure, streaming saturated steam rapidly destroys all pathogenic organisms and spores, and has been found the most complete and efficient practical measure for general purposes. For heavy work with limited space, under expert supervision, the vacuum method with superheated steam is advantageous.

Cold.—It has repeatedly been observed that cold does not destroy pathogenic bacteria, yet the number of micro-organisms is progressively diminished in the frozen article. Therefore, cold is a slowly acting and rather inefficient germicide, as well as an antiseptic. Even *liquid air* does not destroy the viability of all bacteria, but few organisms are able to multiply at or below the freezing temperature.

Mechanical disinfection is chiefly used for the skin and other tissues. Not only does mechanical sterilization remove a great number of bacteria, but, by taking away fat, dirt, and the like, mechanical cleansing facilitates the penetration by chemical substances later used. *Smooth skins* are more readily sterilized by mechanical cleansing than *rough ones*. Polished metal surfaces, free from depression, such as the blades of ophthalmic instruments, are usually rendered sterile by careful wiping with a mixture of ether and alcohol. *Persons with a smooth skin*, free from gross contamination, are able to render their hands practically sterile by so simple a means as thoroughly washing with soap and sterile hot water. The number of bacteria upon the hands of any person bears inverse ratio to the thoroughness and duration of a scrubbing with soap, sterile water, and a hand brush. If the skin is chapped, rough, or abraded, the mechanical or chemical sterilization is much less efficient. For wounds mechanical sterilization includes the excision of bacteria-impregnated tissue by a sharp knife, or *débridement*.

Light.—The ultraviolet rays, the actinic rays from the sun, the electric carbon arc or quartz light have pronounced germicidal action, well marked in the case of the direct solar rays (red and infra-violet rays possess little bactericidal value). The action is enhanced by freedom from dust and fogs, and the absence of interposed media such as glass, which, unless of special composition, interferes with the transmission of the ultraviolet rays. *Bacterial toxins* also may be rendered inert by light. *Tubercle bacilli* are destroyed in from a few minutes to several hours, and practically all pathogenic bacteria and their spores may be destroyed by sufficiently prolonged exposure to strong actinic or solar rays.

Electricity is a feeble bactericide. The results reported are largely due to chemical substances, having a disinfectant action, that are generated by the current.

Desiccation.—Absolute dryness is probably destructive to micro-organisms and their spores. The organisms of the *colon group* are more readily destroyed than those of *tuberculosis* and *diphtheria*, and especially resistant are *bacterial spores*. The tubercle bacillus and spore-forming organisms withstand drying for months. Drying prevents bacterial growth; bacteria cannot multiply without water, hence the value of the dried scab as a wound protective.

Alcohol is a good antiseptic, but a weak germicide. It is most efficient in 50 to 60 per cent. solution, the germicidal value diminishing progressively with the addition or subtraction of water. When heated, the *weaker solutions* are found to be more potent, while many bacteria may be *boiled in concentrated alcohol* without destruction. Too great reliance should not be placed on the sterility of catgut, boiled in alcohol, or of instruments dipped in alcohol and momentarily flamed. Strong alcohol reduces the effectiveness of mercuric chlorid, while sublimate, carbolic acid, lysol, and thymol are more powerful as germicides when dissolved in 50 per cent. alcohol than in water. When applied to moist surfaces of the body alcohol is, of course, diluted, and so a proportionately stronger solution should be used than those found efficient in the laboratory.

Carbolic Acid (Phenol).—When pure, phenol occurs in the form of colorless, needle-like crystals, soluble in about 11 parts of water. For convenience, it usually is liquefied by the addition of a small percentage of glycerin. Phenol precipitates albumin without entirely losing its disinfective action. It is usually employed in strengths of 1 to 5 per cent., its germicidal power then being moderate. Upon the skin it decreases tactile sensibility, renders the skin rough, and, if applied to portions of the body for long periods of time, even in weak solution may produce local necrosis and gangrene. The pure acid is caustic, and is used as an antiseptic cauterant in sinuses, appendectomy, tuberculous abscesses, and the like. Liquefied acid may be immediately neutralized by applying strong alcohol. On account of its irritating and toxic qualities carbolic acid has, at present, a limited use in surgery.

Horsley's wax (carbolic acid, 1 part; olive oil, 2 parts; white wax, 7 parts) is used for arresting hemorrhage from the bone during operations.

Cresol.—The various cresols are: *meta-*, *tri,- ortho-*, and *para-*. All are disinfectants. *Tricresol* has been used extensively as a preservative for antitoxic sera. Cresols are usually employed in combination rather than singly; all combine well with oils and soap, and have the advantage of not corroding metallic instruments.

Liquor cresolis compound (*lysol*) contains about 50 per cent. of cresol mixed with neutral potash-soap, and in water forms a transparent soapy solution. It has been used extensively, especially in gynecologic and obstetric practice, for instruments, hands, and mucous surfaces. It delays wound healing, is irritating to the skin, and should not be used as a wet dressing.

Creolin contains about 4 per cent. of cresol together with soap and phenol, and is a black tarry liquid with penetrating odor, making an opaque, milky solution when mixed with water. It is a less efficient germicide than *liquor cresolis compound*, and has largely been relegated to the destruction of lice, fleas, and other animal parasites.

MacDonald's solution consists of pyxol, 2 parts; acetone, 40 parts; alcohol, 60 parts. It is used for the sterilization of the operator's hands and the operative field.

Cumol is a yellowish, oily fluid, boiling at about 160° C. (331° F.). Catgut, thoroughly dehydrated by dry hot air, may be boiled without injury in cumol, and afterward the cumol may be driven off by dry heat. This is one of the best methods of sterilizing catgut.

Iodin is a wound stimulant and germicide. The official tincture contains 7 per cent. of metallic iodin. One-half strength ($3\frac{1}{2}$ per cent. tincture) is largely used as a skin disinfectant and is efficient if the skin has previously been mechanically cleansed and thoroughly dried. If prevented from evaporating, blistering, ulceration, and necrosis of skin follow. It should be used with care on a delicate skin.

Morton's fluid consists of 10 gr. of iodin, 30 gr. of potassium iodid, and 1 fluidounce of glycerin. It was formerly used for injection into *meningocele* and *spina bifida*.

Liquor iodi compositus (*Lugol's solution*) is a mild antiseptic astringent and stimulant for mucous membranes and wounds. It consists of iodin 5 parts,

iodid of potassium 10 parts, and water 100 parts. It recently has come into use as an internal remedy in the treatment of toxic forms of goiter.

Unguentum iodi, containing 4 per cent. of iodin, is a mild counterirritant.

Chlorid of lime (*chlorinated lime*) consists of a mixture of calcium chlorid and hypochlorid, and owes its efficacy chiefly to the latter. It should contain at least 35 per cent. of available chlorid (U. S. P.), should be dry, friable, and nearly free from the odor of chlorin until moistened. It is an efficient disinfectant in a strength of 1 : 400. As a *hand disinfectant* its value was conclusively shown by Semmelweiss many years ago, in the prevention of puerpural infection. Mixed in a paste with sodium carbonate and water it is one of the most effective *disinfectants of the skin*. About 8 gm., or 2 drams, of chlorinated lime are placed on the palm of the hand, a crystal of sodium carbonate weighing about ½ gm. (8 gr.) added, the mixture moistened with water, and the paste formed, thoroughly rubbed into the hands and forearms, especial care being taken to carry it under the nails and along the ungual folds. The paste is washed off with sterile boric acid solution. If its application is not followed by the application of boric acid or other neutralizing agent, it may render the skin rough and the nails brittle.

Sodium hypochlorite solution (*Labarraque's* or *Javel's* solution) consists of: chlorinated lime, 75 parts; sodium carbonate, 150 parts; water, to 1000 parts. It should contain at least 2.6 per cent. by weight of available chlorin.

Dakin's solution is a fresh solution of hypochlorite of soda; of neutral reaction, containing from 0.45 to 0.50 per cent. of the hypochlorite. It rapidly decomposes on standing, on exposure to the sunlight, and on contact with organic matter. It is irritating to the skin about the wound, which should be protected by a layer of vaselined gauze. It is an easily decomposable antiseptic, of too transient a nature to be used as a wet or moist dressing. It should be employed with a hydraulic system, so that the wound is copiously flushed in every recess with an excess of the solution, at least every two hours, night and day. It is a *surface disinfectant*, and must come in direct contact with the wound, without interposition of gauze or blood-clot. It dissolves silk, catgut, pus-clot, but not blood-clot or linen.

Other preparations of hypochlorite of soda include the solutions: *eusol*, the powder *eupad*, and *chloramin*. *Dichloramin-T* refers to a hypochlorite dissolved in chlorcosane or chlorinated eucalyptol.

Metals.—The development of micro-organisms in moist media is restrained by certain metals, such as silver or gold, probably because traces of antiseptic metallic salts are formed. *Silver*, which is especially well tolerated by the tissues, is used in septic wounds or upon mucous surfaces. Fine silver wire is not extruded, nor, in the presence of infection, does it cause sinuses as do sutures or ligatures of silk, linen, silkworm-gut, or catgut. Silver sutures are retained and, if not removed, often become buried and heal in the wound. Sims' success in closing a vesicovaginal fistula was largely due to his selection of silver wire as a suture material. Silver foil has been used by Halsted as a covering for wounds and skin-grafts.

Mercuric chlorid (*bichlorid, sublimate*) is one of the few antiseptics generally employed in surgical practice. It is easily decomposed and rendered inert by

contact with metals or organic matter, and a film of oil or a coating of albuminous material may prevent its action. It is employed to sterilize the hands or the operative field, and to serve in irrigating solutions for certain wounds. To render it more stable and effective it is often combined with *citric* (Laplace) or *tartaric acid*, or *sodium* or *ammonium chlorid*. Objections to its use are its toxicity, instability, lack of penetrative power, destructive action upon metals, and irritation produced on the skin, mucous surfaces, and in the tissues. It is used in dilutions of from 1 : 500 to 1 : 10,000. The former strength often causes a marked local irritation, erythema, pustulation; the latter is too weak to be trustworthy. To insure a more thorough action the body surface should be thoroughly scrubbed with soap and hot water, all dirt, crusts, grease, sand, and loose epithelial scales carefully removed from the skin, and a fat solvent (such as ether or alcohol) applied before the sublimate solution is used.

Disadvantages.—Corrosive sublimate combines with proteins to form feebly antiseptic albuminates; it corrodes metals, is locally irritating, gives the skin and nails a dark brown color, and, when absorbed, it causes poisoning with salivation, diarrhea, colic, and nephritis.

Toxitabellæ hydrargyri chloridi corrosivi are the official tablets (containing about ½ gm. each of mercuric chlorid and sodium chlorid) for the preparation of solutions of sublimate. They are colored blue or red, and labeled "Poison."

Harrington's solution (*acid bichlorid solution*), consisting of bichlorid of mercury, 1.5 gm.; hydrochloric acid, 100 c.c.; glycerin, 100 c.c.; alcohol (95 per cent.), 1200 c.c.; distilled water, 2000 c.c., is a powerful but irritating antiseptic, used for the disinfection of skin, glassware, non-metallic surfaces, and the like.

Mercuric iodid is insoluble in plain water, but soluble when an excess of potassium iodid is added. It has nearly the disinfective power of the bichlorid, without its instability, irritative action, or destructive effect upon metallic instruments.

Mercuric oxycyanid resembles the iodid, the solutions being less irritating and more stable than those of the bichlorid. It does not coagulate albumin nor corrode instruments, and is used as an external antiseptic in proportions of 1 : 5000 to 1 : 1000.

Mercuric ammonium chlorid (*sal alembroth*) occurs as crystals, freely soluble in water. It is a powerful antiseptic, less irritating than mercuric chlorid, and less prone to form albuminates. It is used in sal-alembroth gauze (containing 1 per cent.).

Mercurophen (*sodium oxymercury orthonitrophenolate*) occurs as a brick-red powder, freely soluble in water, forming an amber-colored solution. It is 50 times as active as mercuric chlorid against the Staphylococcus aureus, is not decomposed by albuminoids, nor does it tarnish nickel-plated instruments. It is a powerful germicide in strengths of 1 : 5000 to 1 : 40,000.

Potassium mercuric iodid is soluble in water and alcohol, less toxic than mercuric chlorid, and is used as a skin disinfectant in the strength of 1 per cent. in 70 per cent. alcohol. It is slightly irritating to mucous surfaces in ½ per cent. solution. When absorbed, it causes headache, irritability, restlessness, muscular twitching, vomiting, purging, depression of the circulation and respiration,

collapse, and coma. Characteristic is the smoky brown or black urine, caused by the formation of hydrochinon and pyrocatechin; the color increases on standing. Albuminous casts frequently occur in the urine.

Formaldehyd (*formic aldehyd*, *methyl aldehyd*, or *oxymethylene*) is a pungent, irritating gas formed by oxidizing the vapors of methyl alcohol. Forty volumes per cent. of the gas are soluble in water, such a solution being sold under the name of *formalin* or *formol*. Under condensation or concentration the gas polymerizes into paraformaldehyd, paraform, hexamethylenamin, or methylenamin which, when gently heated, is reconverted into formaldehyd gas. The gas combines with albuminous substances, rendering them stable and incapable of gastric digestion. It is neutralized and converted into an inert compound by ammonia. Formalin has a destructive action on delicate tissue, renders the skin rough and leathery, and produces distressing skin eruptions. The solution usually employed is 10 per cent, which contains 4 per cent. of the gas. Ten per cent. of commercial formalin in a saturated solution of borax is an efficient disinfectant agent for dental or dressing instruments. The instruments may be left in this solution for hours or days with little corrosion, except from electrolytic action.

Formalin glycerin (Murphy) is a 2 per cent. solution of formalin in pure glycerin, which should stand at least twenty-four hours before use. It is used for injecting joints and serous cavities. It may cause necrosis of muscle and other tissue.

Glutol is a dusting-powder made of formalin, gelatin, and cane sugar.

Formaldehyd sterilizers, in which formaldehyd gas is generated by heating pastils of paraform, are used for the sterilization of catheters, cystoscopes, electric conducting cords, and other forms of delicate apparatus.

Hydrogen peroxid (*liquor hydrogenii dioxidi*) should contain not less than 3 per cent. of H_2O_2. In contact with albuminous matter it gives off from ten to fifteen times its volume in oxygen, producing a bubbling foam. It is deodorant, mildly and very transiently disinfectant, and somewhat hemostatic. It is used for cleansing open wounds and in anaërobic infections. It should not be injected into sinuses or cavities from which the gas cannot readily escape.

Silver Nitrate (Lunar Caustic).—With organic matter, this salt is blackened on exposure to the light. It is easily decomposed, is irritating, but is one of the most efficient disinfectants for mucous surfaces. It is used in solution, solid stick, crystal, or mitigated stick made by fusing with potassium nitrate. It is a dependable, superficial cauterizing agent for excessive or flabby granulations, and is a very satisfactory antiseptic (in 1 : 5000 to 2 per cent. solution) against the gonococcus. Credé's method for preventing *ophthalmia neonatorum* is the instillation of 1 or 2 drops of a 2 per cent. solution of nitrate of silver in each eye in the newborn infant.

Argentoproteinum Mite (N. F.—**Mild Silver-protein**): Protargin mild; argyn, cargentos, silvol, solargentum, silver lactate (actol), citrate (itrol), argyrol, and collargol are organic compounds of silver, soluble, but black and opaque, relatively free from irritation, and capable of being employed upon delicate mucous surfaces up to 25 per cent. in strength. *Stains may be removed* by a 1 : 1000 *sublimate solution*. Stains from nitrate of silver may be

prevented by applying a solution of *sodium thiosulphate* before exposing the part to the light, and removed from clothing by soaking in: bichlorid of mercury 1 part, sodium chlorid 25 parts, water 2000 parts; from the skin by the application of tincture of iodin, followed by ammonia, or potassium cyanid.

Argentoproteinum Fortius (Strong Silver-protein): Protargin strong; protargol, proganol, protargentum, and the like are more irritant and potent, although containing less silver than the "mite."

Boric acid in 10 per cent. or saturated (about 18 per cent.) solution forms a mild, non-irritating lotion, soothing, detergent, and antiseptic, although not germicidal.

Boric alcohol, consisting of 75 parts of a saturated aqueous solution of boric acid and 25 parts of ethyl alcohol, is more stimulating and a more antiseptic solution than plain boric solution. It is useful as a wound lotion, and as a moist wound dressing.

Ball's salicylic solution (*Thiersch's solution*) is made of boric acid, 12 parts; salicylic acid, 2 parts; hot water, 1000 parts. Used for the irrigation of wounds and cavities.

Liquor antisepticus (N. F.) (*Listerine*) consists of boric acid (2.5 per cent.) with thymol, eucalyptol, methyl salicylate, oil of thyme, and menthol in alcohol and water. It is used, diluted four to ten times, chiefly as a mouth wash.

Liquor Antisepticus Alkalinus, Liquor Aromaticus Alkalinus (N. F.) (*Glycothymol*).—A very mild, pleasant, red solution for the mouth, throat, or nose; of a very feeble antiseptic power, containing potassium bicarbonate (2 per cent.), sodium borate (2 per cent.) with thymol, eucalyptol, methyl salicylate, and cudbear in alcohol, glycerin, and water. It is used as a mouth wash, lotion, gargle, or spray, with or without dilution.

Permanganate of potassium is a powerful *deodorant* and *oxidizing agent* valuable in foul wounds. For irrigating the bladder, urethra, intestines, conjunctiva, nose, it is used in strengths of from 1 : 2000 to 1 : 10,000. It may be applied to wounds in a strength of from 1 5 to 5 per cent. It is an oxidizer, rapidly destroyed by contact with oxidizable substances. For *disinfecting the hands* it has been employed as a hot saturated solution, the brown stain being removed by immersion in a warm saturated solution of oxalic acid (Kelly). Permanganate of potash does not irritate the skin, and there is little danger of toxic absorption.

Condy's fluid is a disinfecting solution of sodium and potassium permanganate.

Picric acid (*Trinitrophenol*) occurs in yellow crystals, freely soluble in alcohol, and moderately in water. For *skin sterilization*, a 1 to 5 per cent. solution in 95 per cent. alcohol is painted over the mechanically cleansed operative field. A watery $\frac{1}{2}$ per cent. solution is made by dissolving 5 gm. of picric acid in 100 c.c. of alcohol, and then adding 900 c.c. of distilled water. This is used as a primary application to *burns*. The stains may be removed by a solution containing 1 per cent. each of boric acid and sodium benzoate in water. Absorbed in quantity it colors the secretions and tissues yellow, and may cause death.

Dyes.—Many of the dyes are powerful germicides, especially *malachite*

green, *brilliant green* (used in a strength of 1 : 1000), *pyoctanin*, and *gentian-violet*. The intense staining is objectionable.

Iodoform.—*Triiodomethane* (CHI_3) is a yellow crystalline powder, with a pungent, clinging, objectionable odor. It contains 96 per cent. of iodin and occurs as: (a) Large coarse crystals. (b) Powder from grinding the crystals. (c) Flour, produced by precipitation. It is almost insoluble in water, but is soluble in ether 1 : 7, chloroform 1 : 20, alcohol 1 : 60, oils 1 : 30, glycerin 1 : 100. It may contain living bacteria, and in wounds gives off absorbable and toxic iodin compounds. It may be sterilized by low-pressure steam sterilization, by washing the powder with 1 : 4000 solution of sublimate or other germicide. It stimulates granulation, reduces fetor and putrefaction, and is slightly hemostatic in wounds.

Iodoform gauze, 5 or 10 per cent., is prepared by impregnating sterile cheese-cloth with an emulsion of iodoform powder in glycerin or neutral liquid soap, or, better, with an ethereal solution of iodoform, or the powder.

Iodoform emulsion of 5 or 10 per cent. strength is made by incorporating iodoform powder in glycerin or sweet oil. It is used for the injection of tuberculous joints and cavities. Iodoform is considered especially efficacious in local tuberculous processes.

Objections.—1. *Odor:* This may, in a measure, be covered by the addition of powdered roasted coffee, tonka beans, Peruvian balsam, or turpentine.

2. *Iodoform poisoning:* Local iodoform erythema or eczema occasionally follows contact with the unbroken skin, with redness, itching, irritation, and vesication. In persons with iodoform idiosyncrasy, areas of erythema with papules or vesicles may spread over a large part of the body.

3. *Systemic Complications:* Absorption of iodoform may produce: (a) *Dermatitis.* (b) *Cerebral symptoms*, contracted pupils and rapid pulse, suggesting a meningitis or psychosis, with irritability, moroseness, melancholia, persecutory delusions, delirium, and coma. There is fever, yellowness of the conjunctiva, suffusion of the eyes, metallic taste with iodoform odor of the breath, and emaciation and nephritis. (c) *Gastro-intestinal symptoms* with nausea, vomiting, and diarrhea.

The urine, boiled with a small piece of starch, shows a blue iodin-ring at the line of contact with concentrated nitric acid; or urine shaken with chloroform, after the addition of a few drops of fuming nitric acid, develops a carmin or purple tint.

Boric acid and iodoform dusting-powder consists of 3 parts of boric acid and 1 part iodoform, and has been extensively used in wounds and in brain surgery, especially in the treatment of brain abscesses, by Macewen.

Substitutes for iodoform are the iodin-containing dusting-powders: *thymol iodid* or *aristol* (a grayish-yellow adhesive powder), *xeroform*, *vioform*, and *airol*.

Bipp, Bismuth-iodoform-paraffin-paste (*Rutherford-Morison*), is made by mixing 1 part of bismuth subnitrate with 2 parts of iodoform, and sufficient liquid paraffin to make a paste the consistency of butter. The wound is cleansed or débrided, wiped with alcohol, and the *Bipp* introduced and rubbed by gauze into all surfaces, after which the wound usually is closed. If used in sufficient quantity, bismuth or iodoform poisoning may follow.

Iodoform Balsam (*Mencière's Mixture*): Iodoform, 10 gm.; guaiacol, 10 gm.; eucalyptol, 10 gm.; balsam of Peru, 10 gm.; alcohol, 100 c.c.; ether, to make 1000 c.c. This is applied with a spray, an applicator, or on gauze packing.

Calot's Fluid, No. 1: Iodoform, 10 gm.; guaiacol, 1 gm.; creosote, 5 gm.; ether, 30 gm.; olive oil, 70 gm. The olive oil is sterilized by boiling in a water-bath for thirty minutes, cooled, and the iodoform, guaiacol, creosote, and finally the ether added. It is used for injection into tuberculous joints and abscesses after aspiration, from 10 to 20 c.c. being used.

Calot's Fluid, No. 2: Consists of camphorated naphthol, 2 gm.; glycerin, 12 gm. Two to 12 grams are injected into tuberculous abscesses, when the pus is so thick that it is impossible to aspirate.

Calot's Paste, No. 1: For injection of sinuses. Consists of camphorated phenol, 6 gm.; camphorated naphthol, 6 gm.; guaiacol, 15 gm.; iodoform, 20 gm.; lanolin or spermaceti, 100 gm.

Calot's Paste, No. 2: Camphorated phenol, 3 gm.; camphorated naphthol, 3 gm.; guaiacol, 8 gm.; iodoform, 10 gm.; lanolin or spermaceti, 100 gm. Twenty to 40 c.c. are injected. Camphorated naphthol is made by mixing 2 parts of camphor with 1 part of beta-naphthol.

Whitehead's varnish is used for coating wounds upon mucous surfaces, especially for those left after the removal of cancer of the tongue or mouth. It consists of *compound tincture of benzoin*, in which the alcohol is replaced by a saturated solution of iodoform in ether.

Bismuth powders include: *Bismuth subgallate* (*dermatol*), *xeroform*, *noviform*, and *ABC powder* (consists of equal parts by weight of Acid boric, Bismuth subnitrate, and Calomel).

Bismuth oxyiodid, a brownish-red, insoluble, non-irritating powder, is used as a protective powder for wounds or incisions.

Beck's bismuth paste No. 1 consists of 30 parts of bismuth subnitrate in 70 parts of white vaselin.

Beck's paste No. 2 consists of bismuth subnitrate, 30 gm.; white wax, 5 gm.; soft paraffin, 5 gm.; and vaselin, 60 gm. It is used for injection in sinuses, fistulæ, and open cavities.

Moynihan's antiseptic cream consists of bismuth carbonate, made into a thick paste with a 1 : 1000 watery solution of mercuric iodid, and is used as a dressing for surface wounds.

Bismuth Subiodid Paste: Bismuth subiodid, 50 parts; white petrolatum, 100 parts. Useful as a non-irritating dressing for wounds, abscesses, and sinuses. It may be injected by a syringe as a packing for deep wounds, sinuses, and fistulæ.

Ichthyol usually occurs as *ammonium ichthyol-sulphonate*, a thick, brown, oily liquid obtained by the distillation of bituminous shales possibly containing fossil fish. It contains about 10 per cent. of sulphur, is mildly antiseptic, and locally stimulant and counterirritant. It is used in glycerin, oil, or ointment, in from 5 to 50 per cent. strength for erysipelas, sprains, swollen joints, frost-bites, chilblains, or burns. It is soluble in water, oil, or glycerin. It is used for lymphatic swellings, acute and chronic skin diseases, for hemorrhoids

and fissures. It is also applied in rectal suppositories and used on vaginal tampons.

Liniments are used, in connection with massage, for counterirritation and local stimulation through the unbroken skin. The least irritating is *linimentum camphoræ*. More irritating and, from prolonged action capable of causing vesication, are *linimentum ammoniæ* and *linimentum chloroformi*. *Linimentum saponis* (soap liniment) contains camphor and alcohol, and is alkaline, cleansing, and mildly counterirritant. *Linimentum saponis mollis* (soft soap liniment) contains 65 per cent. of cotton-seed oil soap and is used for cleansing and shampooing. It is strongly alkaline. *Linimentum terebinthinæ* (Kentish's ointment) is an irritant cerate ointment. *Linimentum calcis* (Carron oil), containing equal parts of lime-water and linseed oil, freshly combined, is non-irritating and soothing and, formerly, was largely used for burns.

Unna's paste or hard jelly is used in the treatment of chronic ulcers with eczema. It consists of zinc oxid, 10 parts; gelatin, 30 parts; water, 30 parts. Antiseptics may be added. The mixture is liquefied in a water-bath. It is applied by brush or swab, and covered by cotton or gauze.

Depilatory Powder: *Calcium oxid*, 10 gm.; sodium sulphid, 3 gm.; amyli, 10 gm. These should be ground and mixed dry. Just before using, a thick paste is made with a small quantity of water, and a layer, 2 cm. thick, spread on the part from which the hair is to be removed, with a wooden tongue-depressor. In fifteen or twenty minutes the hair will have softened so that it may be scraped off with the edge of the tongue depressor. Mucous membrane should be protected from the powder by a coating of vaselin.

CHAPTER XI

THE ACUTE SURGICAL INFECTIONS

Pyogenic bacteria are bacteria which produce suppuration without causing a specific fever.

Staphylococcus pyogenes (Pasteur, 1880) is divided, according to the color of the *insoluble pigment* (*lipochrome*) produced on artificial cultivation, into the (1) *aureus*, (2) *albus*, and (3) *citreus*.

1. **Staphylococcus pyogenes aureus** is the most virulent staphylococcus, and the most common cause of localized suppuration.

2. **Staphylococcus pyogenes albus** is less virulent and causes suppuration one-half as often as the aureus.

Staphylococcus epidermidis albus (Welch), of feeble virulence, is commonly found on the skin and often in clean wounds without producing suppuration. It causes suppuration in devitalized tissues, as in the stitch-abscesses from tight sutures, and the suppuration about drains. The *Staphylococcus albus* may reduce the virulence of other bacteria with which it is associated by stimulating protective exudation or adhesions, as when associated with the colon bacillus in peritonitis.

3. **Staphylococcus Pyogenes Citreus** (Passet, 1885). —A relatively infrequent and unimportant staphylococcus, having slight virulence.

The *staphylococcus* is the most common pathogenic organism found on the skin, and the most frequent cause of suppuration. It grows readily on culture-media, is Gram-positive, liquefies gelatin, has a powerful tryptic action, gives off the soluble proteolytic toxin *staphylolysin*, which dissolves red blood-cells, and *leukocidin*, which injures leukocytes. Staphylococci also contain an *endotoxin* which produces positive chemotaxis and fibropurulent inflammation. The injection of killed cultures is followed by suppuration. The staphylococcus resists drying and sunlight, and may remain alive in dust for a month or more; has a thermal death-point of 62° C., and is killed by moist heat at 80° C. in five minutes; by 5 per cent. phenol in two and one-half minutes; by 1 per cent. lysol in thirty minutes; by 4 per cent. lysol in one minute. It produces in culture a transmissible autolytic substance or *bacteriophage*.

Vaccine. A limited immunity, lasting six to twelve months, may be developed by the injection of killed cultures of the staphylococcus.

Antitoxin.—Staphylococcic antitoxic serum is not of practical clinical value.

Pathogenesis.—The staphylococcus is the great cause of pyogenic infections of the skin and bone, and also of many infections of mucous and serous surfaces.

1. *Skin.*—The Staphylococcus aureus causes pustules, furuncles, carbuncles, cutaneous and subcutaneous abscesses. It is found in eczema, impetigo, sycosis, in mastitis, panaritium. Garré, in 1893, produced a crop of boils by rubbing a pure culture upon the unbroken hairy skin of the forearm.

2. *Bone.*—Purulent osteitis, osteomyelitis, and periostitis are usually due to the Staphylococcus aureus. Intravenous inoculations in young animals are

followed by osteomyelitis; in older animals, after such an injection, localization occurs where a bone is bruised or fractured.

3. *Mucous and Serous Surfaces.*—The staphylococcus is commonly found in purulent conjunctivitis, dacryocystitis, tonsillitis, suppurative lymphadenitis, parotitis, arthritis, ulcerative endocarditis, pyelonephritis, phlebitis, meningitis, and abscess of the liver.

4. *Bacteremia.*—Staphylococci do not multiply in the blood, and rapidly disappear from the blood when the source of infection is removed. The staphylococcus, however, is transmitted by the blood, and is the usual cause of fatal pyemia. Metastatic purulent foci (*pyemia*) occur in 95 per cent. of general infections by staphylococci.

Prognosis.—Lack of resistance to staphylococcic infection is found in newborn infants and the aged, in diabetes, and in the debilitated and cachectic. Tuberculous and syphilitic lesions are rendered more virulent by associated infection with the staphylococcus. Unless the normal resistance has been reduced, local staphylococcic infections are readily amenable to treatment. Seventy per cent. of general staphylococcic infections are fatal; therefore the finding of the aureus in the circulating blood is of grave import. Very chronic infection by this coccus causes amyloid changes in the internal organs.

Treatment.—Maintenance or increase of the patient's general resistance, including: 1. *Correction of constitutional disease* or diathesis, such as diabetes, syphilis, or nephritis.

2. *Maintenance of resistance* by hygienic measures including: (a) Sufficient, selected diet; (b) production of normal elimination; (c) sunlight, fresh air, exercise, bathing; (d) the internal administration of mineral acids, iron, and arsenic; (e) sodium cacodylate (0.5 to 1.3 gm.), injected subcutaneously every three to seven days, is useful, especially in the pyogenic infections of the skin.

3. *Artificial Immunity.*—Chronic or recurrent infections are treated by graduated injections of stock or autogenous vaccine, or the bacteriophage.

4. *Prophylaxis.*—(a) *Elimination of Sources of Infection:* With boils or carbuncles, the skin is sterilized by daily baths in weak hypochlorite or chlorid-of-lime solution. Thirty grams of chlorid of lime, mixed with 90 gm. of sodium carbonate are added to 20 gallons of water. (b) *Removal of Foci of Infection*, found in tonsils, paranasal sinuses, jaws, old sinuses, and fistulæ. For the disinfection of local lesions, tincture of iodin, mercurochrome, metaphen, or yellow oxid-of-mercury ointment is used. A 1 : 500 sublimate alcohol is valuable in *acne*. Washing with tincture of green soap, and exposure to the air, is effective for the pustulation of the scalp of infants.

5. *Abortive Treatment.*—For furuncles and carbuncles, the injection of 1 to 3 minims of liquefied phenol by a fine hypodermic needle into the center of the lesion; in periostitis, the early subcutaneous division of periosteum; in osteomyelitis, the early relief of tension by gimlet-holes through the cortex of the bone, will often be followed by rapid subsidence of the infection.

6. *Treatment of Fully Formed Lesions.*—Early incision and free drainage of abscesses (with hot, moist, antiseptic fomentations and local and, often, general rest) are indicated. Large carbuncles are best excised. In staphylococcic

bacteremia, intravenous injections of gentian-violet in 25 per cent. solution (3 mg. per kilo of body weight) has a limited value.

Streptococcus pyogenes (Fehleisen, 1883) has a number of varieties, including the *hemolytic* and *non-hemolytic streptococcus* and the *Streptococcus viridans*. The streptococcus grows slowly in culture-media, is Gram-positive, does not resist drying except in blood or pus, and does not liquefy gelatin. It has a thermal death-point of 54° C., and is killed by 5 per cent. phenol in fifteen minutes. It is normally found on mucous surfaces, as in the mouth, nose, intestinal tract, and vagina. It varies greatly in virulence, becoming more virulent after infecting the animal body, and rapidly attenuating when grown on artificial media. The streptococcus produces a violent local inflammation, with much edema, swelling, hyperemia, serous exudation, and even necrosis or gangrene, but with limited pus formation. It causes erysipelas, cellulitis, arthritis, peritonitis, purulent pleurisy, septicemia, and pyemia. It may remain in the tissues for many months, especially the hemolytic form, being relighted into activity by traumatism, as in reoperation.

Streptococci pass from the blood into the gall-bladder and bile, and multiply in the walls of the gall-bladder. They pass through the kidney after a delay of four to six hours, with primary injury of the epithelium and, at times, the production of intra- and peri-renal abscesses.

The term "streptococci" covers a variety of different organisms, as shown by the variety of lesions produced. Thus, *streptococcal infections of wounds* do not usually spread on the skin as does *erysipelas*. *Erysipelas* also differs from *cellulitis* in the absence of suppuration. The *Streptococcus viridans* is disseminated largely through the blood-stream.

Skin diseases due to streptococci include *Impetigo contagiosa*, *Pemphigus neonatorum et infantum*, *Dermatitis exfoliatus epidemica*, *Sycosis barbæ* (*coccogenic sycosis*).

Streptococcic Septicemia.—Streptococci multiply in the blood. The streptococcic bacteremia is very serious, although less fatal than the staphylococcic form. Very dangerous is the *streptococcic bacteremia of physicians* from accidental inoculation during operation upon an infected patient. In from two to six hours there is local pain and inflammation, followed by red cutaneous lines that streak to adjacent lymph-nodes, with progressive lymphadenitis, chill, high temperature, and nervous stimulation with delirium. After the first few hours the process has spread beyond the reach of any local measure, and handling, probing, squeezing, incising, scraping, or amputating the part only reduces the local resistance and favors a general and fatal bacteremia.

The *extraction of a molar tooth* for streptococcic inflammation of the alveolus may be followed by a fatal bacteremia, especially if the area of inflammation is then repeatedly incised or curetted. Squeezing and scraping are especially reprehensible in streptococcic infections.

In the severe *influenza* epidemic of the late war the hemolytic streptococcus entered the respiratory tract and produced, in the less resistant, an intense polyserositis, the pleural, pericardial, or other cavities rapidly filling with clear or turbid serum. These patients often died within twenty-four or forty-eight hours, especially when subjected to early manipulation or operation.

The utmost rest and quiet should be enjoined in the early days of streptococcic infection.

The *Streptococcus viridans* is commonly found about teeth and in alveolar abscesses. In animals it has a low virulence, but, entering the blood-stream, in man, it causes malignant endocarditis, chorea, cholecystitis, appendicitis, and possibly gastric ulcer.

Streptococcus mucosa is a somewhat attenuated form which has been found in the sputum.

Local streptococcic infections have a very short (few hours) incubation, a marked early edema, and a tendency for rapid spread through the lymph-vessels. 1. *Erysipelas* is a spreading infection of the skin and subcutaneous tissues, due to the *Streptococcus erysipelatis*, having little tendency to suppuration.

2. *Phlegmonous Erysipelas, Cellulitis, Cellulocutaneous Erysipelas:* A form probably due to special variety of streptococcus, characterized by wide-spread necrosis and suppuration of the subcutaneous tissues.

3. *Noma:* A streptococcic infection with necrosis and gangrene of the skin and subcutaneous tissues of the cheeks, lips, and external genitals, occurring in debilitated children especially after measles, scarlatina, or other acute exanthemata.

4. *Follicular infection of axilla (hydradenitis of Verneuil)* may be of streptococcal origin.

5. *Ludwig's angina* is a diffuse streptococcal infection of the sublingual tissues and floor of the mouth.

Erysipelas (St. Anthony's Fire).—An acute spreading contagious inflammation of the skin and subcutaneous tissues, due to the streptococcus.

Etiology.—*Streptococcus erysipelatis* (Fehleisen, 1884) is present in the spreading edge of the lesion, and in the lymphatics. It occurs especially in men, in the third decade and during the spring months. Infection is by contact, abrasion, surgical operation or childbirth, and is favored by alcoholism, nephritis, diabetes, and debility. Relapses and recurrences are common. It occurs on the face and scalp in 80 per cent. of the cases; leg, foot, and other regions in 20 per cent.

Varieties.—1. *Facial erysipelas* involves the cheeks, nose, lips, and eyelids, with or without preceding wound or abrasion.

2. *Faucial erysipelas* spreads from the face to the pharynx and epiglottis, often with great edema, sloughing, or ulceration.

3. *Scrotal erysipelas* is characterized by great edema and, at times, necrosis.

4. *Gastro-intestinal* infection occurs with diarrhea.

5. *Erysipelas neonatorum*, a septic thrombosis through the umbilical veins to liver, in the newborn, with internal metastasis and death on the sixth or eighth day.

6. *Phlegmonous* or *cellulocutaneous erysipelas* (*cellulitis*) occurs in the debilitated, dissipated, or diseased (nephritic), with high fever, necrosis, and sloughing of fascia and subcutaneous tissues, gangrene of the skin, involvement at times of periosteum, bones, joints, eyes, meninges, often with exhaustion and the typhoid state.

Pathology is that of a progressive lymphangitis of the skin. The cocci are

most abundant at the margins of the erythema. There is a cellular serous or serofibrinous infiltration with erythema. Vesiculation, at times gangrene (*gangrenous erysipelas*) or metastasis to internal organs, occurs. On the skin there is secondary desquamation, absorption, pigmentation, and fading.

Symptoms.—The onset occurs within a few hours after inoculation, with malaise, rigors, and pyrexia. The involved area of skin is vivid red, hot, edematous, tense, with gyrate, sharp, raised red borders and, at times, vesicles and bullæ. The adjacent lymph-nodes are enlarged and tender. Desquamation and discoloration of the skin remains after the acute swelling subsides. The general symptoms are severe, with high temperature (102° to 105° F.), chills, vomiting, delirium, albuminuria, more rarely pneumonia, pyemia, septicemia, and, from the facial form, secondary edema of the glottis and meningitis. Necrosis and suppuration of subcutaneous tissues is characteristic of *phlegmonous erysipelas* or *cellulitis*. The cutaneous form continues from two days to several weeks, and is followed by fading and exfoliation.

Prognosis.—A self-limited infection, tending to subside on the fourth or fifth day or after three weeks, except in infants, the aged, dissipated, or debilitated, in whom the mortality is high. Relapses and recurrences are frequent. Facial erysipelas is especially dangerous.

The sequels are *lymphadenitis*, *rheumatism*, *serous infections*, *endocarditis*, *phlebitis*, *nephritis*, and *neuritis*.

Treatment.—1. *Prophylactic.* The removal of septic foci (in relation to the tonsils, teeth, accessory sinuses, gall-bladder, appendix, chronic sinuses, fistulæ, or ulcers) is desirable, with the injection of an appropriate toxin-antitoxin. The infected patient should be isolated, and antiseptic precautions taken to prevent the spread of the infection. Rubber gloves should be worn by nurses and surgeons during operations and dressings, and in the examination of the mouth, vagina, and rectum.

2. *General Treatment.*—In streptococcic infection absolute local and general rest is essential. The patient frequently is greatly harmed by repeated examinations, by being moved, or by an ambulant treatment. Local movement, manipulation and operation, in the early stages tend to spread the infection; and in these infections meddlesome surgery is especially dangerous. Absolute rest in bed, a simple liquid diet, an excess of liquids, with rest and protection of the inflamed area, are essential for the lowest mortality. Tincture of the chlorid of iron (in doses of 10 to 20 minims in water, given every three hours) is a time-honored treatment.

3. *Antitoxin*, as a rule, has been of little value, because it has not been used early enough or in sufficient dosage; or from failure to use a serum corresponding to the type of infecting streptococcus. Recently, encouraging advances have been made in the preparation and use of streptococcic sera. Streptococcus vaccine has no value in acute streptococcic infections.

4. *Blood* or *serum transfusion*, especially from a patient of corresponding type who has recovered from a streptococcic infection or has been treated by injections of streptococcic vaccine, is worthy of trial for the desperately sick patient.

5. *Blood Disinfection, Therapia Sterilisans Magna.*—The intravenous in-

jection of a 1 per cent. mercurochrome solution is used in the proportion of 5 to 8 mg. per kilo of body weight. It produces such violent reactions and such serious toxic action upon the parenchymatous organs, especially the kidneys, that its use should be restricted until the value of the injection is more definitely shown.

6. *Local Treatment.*—Evaporating lotions of the solution of aluminum acetate, or boric alcohol, are cooling and soothing. As an early prophylactic dressing a coating of the yellow oxid-of-mercury ointment has value. In erysipelas, the area and especially the advancing edge of the inflammation may be painted with tincture of iodin ($3\frac{1}{2}$ per cent.), mercurochrome (1 per cent.), or metaphen (1 : 1000 to 1 : 5000). Mucous surfaces may be swabbed or sprayed with one of the two last-mentioned solutions, or with the less toxic tincture of the chlorid of iron in glycerin.

If the skin tension is extreme, and necrosis or gangrene threatens, sharp clean-cut *incisions* are made, with the least possible traumatism, to relieve tension. In edema of the glottis and in Ludwig's angina, early incisions to relieve tension are desirable. In cellulitis, free early incisions should be made to provide drainage and exit for sloughs, and wet antiseptic dressings continuously applied. With very extensive cellulitis of the leg, *amputation* may be necessary to save life.

Erysipeloid is an infectious dermatitis resulting from inoculation by dead or decomposed material, from fish, crabs, oysters, or cheese.

Symptoms.—Two or three days after a crab-bite or other injury, a painful red swelling with local temperature and throbbing occurs, and a sharp red line of demarcation forms. The temperature, pulse, and tongue are not disturbed. There is no suppuration, but papules, vesicles, or pustules develop, as a rule. Lymphadenitis is rare.

Treatment.—A plaster of 2 per cent. salicylic acid, or a lotion of 2 per cent. aluminum acetate should be applied for three days, followed by a simple ointment. Intramuscular injections of swine erysipelas immune serum are very useful (von Redwitz).

Pneumococcus (Sternberg, Pasteur, 1880) is an encapsulated diplococcus staining by Gram's method, growing slowly and feebly on artificial media, commonly found in nasopharynx and mouth. It has a thermal death-point of 52° C. It is a common cause of lobar pneumonia, meningitis, empyema, endocarditis, otitis media, arthritis, and, rarely, peritonitis and osteomyelitis. There are four chief types of the organism. It does not resist the sun or drying except when dried in blood or sputum.

Treatment.—For type I pneumococcus infection, type I serum is valuable and should be given early. Injections of pneumococcus antibody solution are valuable against type I, less effective against type II infection, and useless against type III infection. Pneumococcus vaccine evokes such a slow immune response as to be useless except as a possible prophylactic treatment. Cinchonization by quinin or the use of ethylhydrocuprein hydrochlorid injections seems to have value.

Bacillus coli communis (Escherich, 1886) is normally found in the intestinal tract, air, soil, and water. It is more virulent when derived from dis-

eased bowel or suppurative lesions, and is a motile flagellate bacillus, readily growing on culture-media, with the production of indol, gas, and acid; and of specific agglutinins. It is Gram-negative, and in the bile, like the typhoid bacilus, precipitates cholesterin. Is the most common cause of cystitis; a frequent cause of pyelitis (80 per cent. of urinary-tract infections); is often found in cholecystitis, appendicitis, peritonitis; rarely in bones, joints, and soft parts. The produced pus gives off a characteristic fecal odor. Except when incorporated in a favorable medium it is rapidly killed by drying, and is readily destroyed by dilute solutions of carbolic or hydrochloric acid, or the undiluted normal gastric juice. The thermal death-point is 60° C.

Bacillus Pyocyaneus.—A motile, flagellate, Gram-negative bacillus, causing greenish-blue pus, with slight toxic action in superficial wounds. It may be more virulent in peritonitis, septicemia, or pyemia. It is frequently found in chronic bone abscesses, in middle-ear disease, in endocarditis, and pneumonia.

Chronic pyocyaneus infection is a cause of summer diarrhea in children, and of epidemic dysentery with necrotic and pseudomembranous inflammation of the entire alimentary tract. In the esophagus the ulcers or necrotic areas involve the submucosa. There is an associated hyperplasia of the lymphoid tissue, and the Bacillus pyocyaneus is present in large numbers. Involved intestine is dilated, the psoas muscle paralyzed. The cutaneous lesions are usually erythematous, and may suggest acute exfoliative dermatitis or leprosy.

Usually the organisms remain local, causing local inflammation and general symptoms from absorption of toxin. The toxin causes a paralysis of smooth muscle; dilatation of the intestines with marked hypomotility, which may also involve the stomach; dilatation of the bronchi with, at times, great emaciation and prostration. However, severe general effects from wound infection by the pyocyaneus are rare. The green color is produced only when an abundant supply of oxygen is present.

Gonococcus (Neisser, 1879) is a Gram-negative organism. It is easily killed by alkalies, soap, antiseptics, by drying except when in albuminous material. Silver salts are especially effective (nitrate of silver, 1 : 50 to 1 : 5000; argyrol 20 per cent., protargol 10 per cent., etc.). It is killed by a temperature of 45° C. It has a predilection for mucous and serous surfaces, but no pathogenic action on the skin, subcutaneous tissue, fat, or muscle. Stratified squamous epithelium is protective. Abdominal incisions that have been in contact with gonorrheal pus only may be closed without drainage, and heal without redness or inflammatory reaction.

Mucous surfaces lined by columnar epithelium and their tributary mucous glands are most frequently involved by the gonococcus. After an inoculation of three to five days, a virulent catarrh starts with a seromucous discharge, becomes purulent in three to five days, runs an acute course of about six weeks, and then passes into a chronic stage with a watery discharge (gleet), and finally into an inactive stage which is subject to exacerbations and, if improperly treated, may continue throughout the lifetime of the patient. The gonococcus invades the cells covering the mucous membrane, and is difficult to dislodge. In mucus-lined canals with a small outlet, as in *Bartholin's gland*, *Cowper's gland*, or the *fallopian tubes*, abscesses may form. In the conjunctival sac a violent inflamma-

tion is produced, with a tendency to ulceration, opacity, or perforation of the cornea. As *Ophthalmia neonatorum* it is the greatest cause of blindness. While severe gonorrheal proctitis occurs rarely, violent inflammation of the mouth, air passages, or upper digestive tract is almost unknown. Lymphatic extension and enlargement does not occur from a pure gonorrheal infection. Certain serous surfaces are involved. A *gonorrheal arthritis* frequently occurs during acute gonorrhea. Several joints are often affected, the disease persisting in a single joint, usually the knee, ankle, or wrist. Ninety per cent. of the patients are males. It differs from rheumatoid arthritis in being finally monarticular, and in that the fluid is turbid or purulent. There is an associated periarthritis, often with involvement of the tendon sheaths. It is not influenced by the usual antirheumatic drugs. The pain is often out of proportion to the local signs. Rheumatoid arthritis attacks the intervertebral, temporomaxillary, sternoclavicular, and sacro-iliac joints, which rarely are involved by the gonococcus.

In the vascular system, gonococcemia with vegetative or ulcerative endocarditis is very fatal.

The Peritoneum.—While the pelvic peritoneum is often involved by extension from the fallopian tubes, with a productive exudate and adhesions, the general peritoneum is rarely seriously involved. Frequently a film of milk-white pus is seen between the intestinal coils, without local hyperemia or other evidence of irritation, except in the pelvic organs. Drainage is not required for gonorrheal peritonitis.

Tendo-achillis bursitis and a *periostitis of the os calcis* with exostosis and spur formations occur.

The gonococcus is especially vulnerable to the *organic* and *inorganic silver salts*. The efficacy of a 2 per cent. solution of silver nitrate (*Credé's method*) in preventing or aborting gonorrheal ophthalmia is a good example. For the chronic inflammations of mucous surfaces it may be impossible to obtain germicidal penetration to the deeply embedded micro-organisms. *Gonococcus vaccine* is of occasional value. An antitoxin has not been developed.

Gas-bacillus Infection: *Gas gangrene* (Maisonneuve, 1853), *gangrene foudroyante, primary mephitic gangrene, acute gangrenous edema.*

Etiology.—A number of organisms cause gas infection: 1. *Bacillus Welchii* (*Bacillus aërogenes capsulatus*) is the greatest gas producer. The infections are usually localized and self-limited from the inhibitory influence of the gas produced.

2. *Bacillus sporogenes* in symbiosis, splits protein, forms ammonia and neutralizes carbon dioxid, causing a virulent massive, spreading gangrene.

3. *Bacillus of Malignant Edema* (Koch-Gasky, 1891). *Vibrion septique* (Pasteur).

4. *Bacillus reglillus crogrediens* (Barney and Heller).

5. *Bacillus meyerillus* (Sabowa).

Some of these organisms are proteolytic, others saccharolytic. They are found in the soil, in the intestines of man and herbivorous animals, in feces, wads of shotgun shells, and woolen clothing. The organisms grow best in devitalized muscle. The circulation in muscle is largely terminal. Gas infection is favored

by the carbohydrate in muscles, and the tissue tension from the presence of gas and liquid exudate. Usually the infection develops in from two to thirty-six hours after the injury, rarely two or three weeks later or following a secondary injury.

Symptoms within the first twenty-four hours: (1) *Pain*, disproportionate to the amount of injury. (2) *Mental stimulation*. (3) *Protracted shock*. (4) Dirty, greenish-gray *membrane over the wound*, with characteristic odor and reddish offensive serum, reddening of the wound edges and bronzing of the adjacent skin, which is later followed by crepitation.

The *diagnosis* may be made within three or four hours by submerging infected tissue under melted agar for gas formation. The Roentgenograms may show bubbles of gas in the tissues six or more hours after injury.

Treatment.—Early débridement. Two hundred c.c. of *tetanus perfringens antitoxin serum*, repeated in six to twenty-four hours. Free opening of wound, wet, hydrogen peroxid (1 : 4) or permanganate of potassium (1 : 500) dressings, transfusion, early amputation if necessary. (See also Gas Gangrene.)

Tetanus (*Lockjaw*) is a bacterial toxemia, characterized by tetanic spasms, and produced by infection with the anaërobic spore-forming *Bacillus tetani*.

Pathology.—Infection usually results from wound inoculation, with a resulting toxemia that involves the central nerve-cells. The tetanus bacilli and their spores remain localized at the site of inoculation, and exert their action through the toxins *tetanospasmin* and *tetanolysin*. Tetanospasmin is the more important, being twenty times more powerful than dried cobra-venom, affecting chiefly the central nervous system, which it probably reaches by way of the motor nerve-tracts, the peri- and endo-neural lymph-spaces, or indirectly by the blood-stream. The wound may or may not suppurate, according to associated contamination. The nerves, cord, and brain show a non-characteristic hyperemia, with exudation and chromatolysis of the ganglion cells.

Etiology.—1. *Bacillus tetani* (Kitasato, 1889): An anaërobic, liquefying, moderately motile, spore-forming bacillus; normal habitat the intestines of herbivora, less frequently the intestines of man. The bacilli are found in feces, manure, hay dust, horse-hair, old mortar and masonry, thorns, court-plaster, and garden or cultivated soil, especially in the New Hebrides, parts of France, Long Island, and New Jersey.

2. *Infants* and the *colored race* are very susceptible.

3. *Hot climates* favor infection.

4. Infection is *favored* by deep punctured, lacerated, and contused *wounds*, especially those produced by gunshot, toy pistols, blank cartridges, rusty nails. Infection has followed vaccination, subcutaneous injections of gelatin, use of catgut, and douches of muddy water containing creolin.

5. *Mixed infection* in the wound by oxygen-using bacteria causes anaërobic conditions favorable to the development of tetanus.

The spores are killed by boiling at 100° C. for five minutes, but resist 5 per cent. phenol or formaldehyd for fifteen hours, and drying for more than ten years.

Varieties.—(1) *Tetanus neonatorum*, from infection of the umbilical stump. (2) *Traumatic tetanus*, following a wound. (3) *Idiopathic tetanus*, wound of entry not evident. (4) *Puerperal tetanus*, through the uterine lining, may

follow intra-uterine manipulation or a douche. (5) *Cephalic* or *head tetanus*, chiefly involving the cranium.

Symptoms.—The incubation period is from three to thirty or more days.

Early Signs: Muscular rigidity, painful cramps or spasmodic twitching in the vicinity of the wound; difficulty or delay on swallowing or in opening the mouth; increased rigidity of the facial muscles, spastic smile (*risus sardonicus*), difficulty in protruding the tongue; increase in reflexes, as knee- and ankle-jerks; difficulty in micturition, and occurrence of occasional generalized tetanic spasms.

Convulsions begin with stiffness of the neck followed by trismus, and then risus sardonicus, opisthotonos, orthotonos, pleurathotonos, or emprosthotonos. The spasm is tetanic, is excited by slight external irritation, and does not quickly subside. There may be apyrexia or pyrexia. Usually the temperature reaches 109° or 110° F. before death. Death results from cramp asphyxia, syncope, or exhaustion. *Cephalic tetanus*, occurring from a wound in the distribution of the fifth nerve, is associated with facial palsy, stiffness of jaw on the same side, and dysphagia.

Diagnosis should be made before the classic symptoms of risus sardonicus and lockjaw appear. Often the first symptom is a local spastic rigidity in the wounded limb, which may persist for weeks. *Tetanus should be suspected if the muscles about an accidental wound are harder or more rigid than the muscles of the uninjured limb or side.*

In *strychnin poisoning*, the rigidity does not begin about the jaws, and relaxation occurs between paroxysms. In *hydrophobia*, there are clonic spasms; in *tetany*, the characteristic spasms begin in the extremities.

Prognosis.—With the proper use of tetanus antitoxin: (1) Before development of symptoms, favorable. (2) At onset of symptoms, fair. (3) With fully developed symptoms, unfavorable.

One hour's delay in the use of antitoxin may result in death.

The prognosis is better in tetanus developing ten days or more after inoculation and in cephalic tetanus. In the febrile form, in children, and when the spasms are violent and generalized the prognosis is bad. After convulsions develop, the mortality in tetanus is about 85 per cent., a 95 per cent. mortality occurring when spasms begin within ten days of the time of infliction of the wound. Under serum treatment the mortality is 24 to 42 per cent., depending upon the duration of incubation, and the promptness, amount, and method of administration.

Prophylaxis.—Great care should be taken to prevent infection of the umbilical stump, in rectal operations, in vaccination and subcutaneous injection, in the sterilization of gelatin, catgut, or other animal products to be placed in the tissues, and in the treatment of punctured, lacerated, and gunshot wounds. These wounds should be thoroughly cleansed and badly lacerated and necrotic tissue cut away. The more careful the excision, the less frequently does tetanus follow. A 1 per cent. solution of silver nitrate destroys the spores in one minute; a 1 : 1000 solution, in five minutes. This or a 3 per cent. tincture of iodin should be employed to sterilize the wound. The cautery should not be used, as it produces necrotic tissue, favoring the development of the tetanus bacillus. Balsam of Peru when introduced into wounds containing earth, the

micro-organisms of malignant edema and tetanus, and tetanus toxin shows distinct antiseptic and antitoxic action (Brunner and Silberschmidt).

Antitetanic Serum.—The prophylactic dose is 500 units. For deep, badly contaminated wounds, or those with complicating fractures, 1000 to 15,000 units should be used. If the wound is two days old, 1000 to 15,000 units. All cases of trench-foot, even if no obvious skin lesion exists, should have antitetanic serum. The wound should be kept open and exposed to the air until healing has taken place. As the antitoxin is gradually eliminated, little remains after ten days; hence a second immunizing dose may be given seven to ten days later; or, if the wound is a very severe one and has not thoroughly healed, a third dose ten days after the second.

For wounds of war repetition of the prophylactic dose was urged by the English Tetanus Commission, which advocated four doses at intervals of seven or eight days for all severe wounds, two doses for men with slight wounds.

During the war, the French noted that the period of immunity produced by injected antitoxin lessens with each succeeding injection. After the first injection it is twenty-one days; after the second, seven or eight days as a maximum; after the third dose, an even shorter time. Therefore, for gunshot wounds, secondary operations should invariably be preceded by a prophylactic injection of 15,000 units, two days before the operation, for tetanus spores may be dormant, but become active from the operative manipulation. Especially is this true with wounds involving bone or complicated by retained foreign matter, even if the wounds have healed.

When spasms begin the tetanus toxin, having combined with the cells of the central nervous system, is not easily neutralized by the antitoxin. When the antitoxin is given (1) *subcutaneously*, forty-eight hours may elapse before full absorption; (2) *intramuscularly*, about twelve hours before absorption; (3) *intravenously*, there is the risk of anaphylaxis. During the war no case of tetanus in France recovered if treated by the intravenous route alone. Chief reliance, therefore, is to be placed on the intradural injections which, also, are less often followed by anaphylaxis. A concentrated serum should be used, so that not over 20 c.c. is injected intraspinally at one time, a corresponding amount of cerebrospinal fluid first being withdrawn. Thirty thousand units of the tetanus antitoxin are given intravenously and 20,000 intraspinally every twenty-four hours for the first three days, together with a single intramuscular injection of 10,000 units. The dosage for children should be almost as great as for adults. If the patient responds promptly, the injection is omitted on the third day. The earliest possible massive treatment is essential.

Desensitization to prevent anaphylaxis is accomplished by the intravenous use of 5 c.c. of serum diluted with 50 c.c. of normal saline. One c.c. of the mixture is injected intravenously. Four minutes later 3 c.c. of the dilute serum are given; two minutes later 10 c.c. of the dilute serum are injected; after two minutes more 25 c.c. are used; after a further delay of fifteen minutes, the full dose of serum may be given intraspinally, intramuscularly, or subcutaneously.

After development of spasms, local operative treatment of the wound should be avoided. The wound should be kept open, but not irritated. The patient

should be isolated, protected from noise, movement, or other disturbance. Careful nursing, fluid diet, and sedatives are important. Injections of carbolic acid or magnesium sulphate, although depressant and sedative, are without curative value. Sedatives, such as *morphin*, gr. $\frac{1}{4}$ (gm. 0.016), given by hypodermic injection every four hours, and *potassium bromid*, *chloral*, *chlorbutanol*, *paraldehyd*, given by mouth or rectum, are used to allay the spasms.

Anthrax (*Malignant Pustule*, *Wool-sorter's Disease*, *Splenic Fever of Animals*).—An acute contagious disease contracted from animals or animal products, chiefly from cattle and sheep, producing in man a local cutaneous lesion (*malignant pustule*), a pulmonary infection (*wool-sorter's disease*), a bacteremia (*anthrax septicemia*), or, rarely, an enteritis.

Etiology.—The *Bacillus anthracis* (Pollender, 1849; Davaine, 1863) is a large facultative aërobic, Gram-positive, spore-bearing, rod-shaped bacillus with square-cut ends. The spores, which are not formed in living tissues, are extremely resistant to heat, drying, and antiseptics, but are killed in four minutes by boiling at 100° C., or by a dry heat of 140° C. continued for three hours.

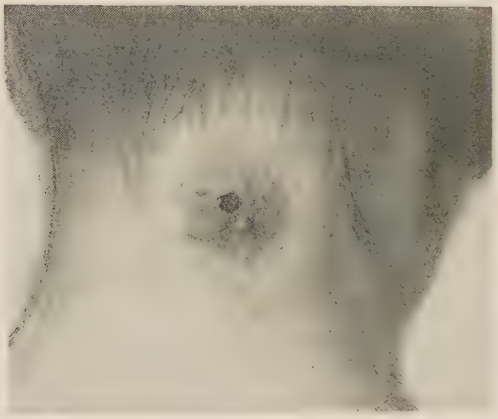


Fig. 48.—Malignant pustule of the neck showing central black area of necrosis, the adjacent skin being reddened and dotted with vesicles.

Dried spores retain their vitality for several years. *Free oxygen is essential*, for carbonic acid retards sporulation. Sporulation, therefore, does not occur in the animal body. The bacillus is pathogenic for cattle, sheep (except Algerian sheep), horses, swine, mice, guinea-pigs, and rabbits. Rats, cats, dogs, and chickens are but slightly susceptible. Infection occurs from association with infected animals or their products, especially in the handling of wool, hides, hair, bristles. In a number of instances shaving-brushes, having contaminated bristles, were responsible.

Symptoms.—1. *Cutaneous type:* (a) *Malignant pustule;* inoculation is usually upon the face, back of neck, or arms. The part itches, and in one to three days a papule forms which becomes vesicular, contains clear or bloody fluid, and develops central necrosis. Typical malignant pustules present by the second or third day a central brownish or black eschar, surrounded by a ring of small vesicles upon a zone of red, brawny, and edematous skin. There is no

pus formation, and but little pain or tenderness. The tributary lymphatic glands are enlarged. Severe general symptoms follow, with faintness, normal or high temperature, circulatory failure, and collapse. Death may occur in three to five days from a secondary anthrax septicemia which is favored by local irritation, movement, and manipulation. (b) *Anthrax edema*, a rapidly spreading, brawny edema without pustulation, usually begins on the eyelid; occasionally other parts of the head, the neck, hands, and arms. Gangrene may follow. Death occurs in three to five days. Bacilli appear in the blood just before death.

2. *Pulmonary anthrax* (*wool-sorter's disease*) is characterized by infection through the lungs with pneumonitis. There is rapid onset with chills, high temperature, rapid respirations, rapid and feeble pulse, cough, pulmonary edema, necrosis of air-passages, enlargement of cervical lymph-nodes, expectoration of much frothy mucus, gelatinous edema of the chest wall, enlargement of the spleen, at times meningitis, and finally collapse and death in from two to seven days.

3. *Intestinal anthrax* is rare, probably derived from the eating of diseased meat, and is characterized by chill, moderate fever, vomiting, diarrhea, pains in the back and legs, enlargement of the spleen, and collapse.

Diagnosis is made by finding the characteristic bacilli in the lesion, by inoculation into mice or guinea-pigs, and by the precipitin test.

Prognosis.—(1) *Malignant pustule* gives a mortality of about 15 to 26 per cent. when upon the face, 10 per cent. when upon the upper extremity, and 5 per cent. on the legs. The cervical infections are especially dangerous. The mortality is increased by the lack of early treatment, and by local operation or manipulation which favors the development of anthrax septicemia. (2) *Anthrax edema* occurs in patients with lowered resistance and is fatal. (3) Recovery from *pulmonary* or *intestinal anthrax* is unusual.

Treatment.—*Malignant pustule:* Absolute rest in bed, protection of the infected area from all manipulation, the part being covered by a thick layer of yellow oxid-of-mercury ointment, or a protective cotton pad, and bandage. Excision, cauterization, or even injection of a $2\frac{1}{2}$ per cent. solution of phenol about the lesion should be avoided. The mortality of operative treatment is 43 per cent.; of non-manipulative treatment and absolute rest, 7 per cent.

Sclavo's anti-anthrax serum is made from animals that have been hyperimmunized, and gives immunity to animals injected with it. Injections of 50 to 100 c.c. are given intravenously in the severe cases, intramuscularly in the milder ones.

In animals immunity is produced by inoculating with anthrax bacilli grown at a temperature of 42° C. (Pasteur).

Hydrophobia (*rabies, lyssa*) is an acute contagious disease, conveyed by inoculation of open wounds by a virus found in the saliva of rabid animals.

Etiology.—The disease may occur in any warm-blooded animal, in order of frequency: dogs, cats, wolves, cows, pigs, skunks, deer, men. The causal organism, not clearly identified, is found in the saliva, salivary glands, thyroid, adrenals and, at times, in the milk of rabid animals. The *virus is attenuated or destroyed* by drying, by action of sunlight, or by the peptic ferment, and is killed by a temperature of 60° C. for one-half hour, by solutions of formalin, phenol,

sublimate, and potassium permanganate. In the spinal cord, the virus is destroyed by drying for fifteen days. It passes through the coarser porcelain filters (Berkefeld filter). Rabies chiefly affects the central nervous system, to which it is conveyed by the peripheral nerves. *Infection* more surely follows bites on exposed parts of the body richly supplied by nerves, as the face or fingers. Inoculation is less certain, and the incubation more prolonged, where the bite occurs through clothing which may wipe virus from the teeth of the animal, or on parts of the body (as the back and legs) having a poor nerve-supply. Inoculation follows the bite, or the licking of an abraded surface or open wound by a rabid animal. Not infrequently the difficulty in swallowing, shown by a rabid pet animal, has induced the owner or veterinarian to introduce his hand into the animal's mouth and throat in search for an obstructing bone or other foreign body. The possibility of a rabid mother infecting the infant in suckling is to be remembered.

Characteristic lesions are the Negri bodies (Negri, 1903)—round, square, or rectangular structures, 0.5 to 0.18 μ in diameter, having a hyaline cytoplasm and containing chromatic bodies that are found in connection with the cells of the central nervous system, where they appear four to eight days after inoculation. They are found especially in the *cornu ammonis* (*hippocampus major*), and also in the cerebral cortex, gray matter of the cerebellum and spinal cord.

Fixed Virus.—By repeated passage through rabbits the virus is intensified, so that the incubation period after inoculation is reduced from twelve or fourteen days to six or seven days, where it remains fixed. This is the *fixed virus* of Pasteur. By passage through monkeys the virus is weakened.

Symptoms.—*Incubation Period:* With an average of about forty days, the period of incubation varies from fourteen days to seven months, being shorter in children. The bite usually heals without evidence of unusual infection. The disease shows three stages, namely: (1) *Depression.* (2) *Excitement, mania,* and *convulsions.* (3) *Paralysis.*

If the second stage predominates, it is called *furious rabies.* If the paralytic stage predominates, it is termed *paralytic* or *dumb rabies.* (1) The *stage of depression* lasts for one or two days and is characterized by melancholia, intolerance of noise or excitement, fear, oppression, slight increase in temperature and pulse-rate, husky voice, and beginning difficulty in swallowing. The healed wound may be slightly painful. (2) *Stage of excitement* is shown by marked mental irritability, terror, and severe painful spasms, involving chiefly the larynx and respiratory muscles. In man the sight or thought of water may cause violent convulsive dysphagia. During the spasms there is intense dyspnea, and secretion of much viscid saliva which hangs from the mouth. Clonic spasms of the diaphragm may occur, producing sounds likened to a dog's bark; or maniacal attacks may, rarely, develop, with attempts to bite others. The reflexes are increased; the pupils, at first contracted, later become dilated and fixed. The temperature may reach 102° or 103° F., the pulse becoming rapid and weak. Death occurs in a convulsion or in the succeeding paralytic stage, in which there are tremor, marked weakness, and spreading, diffuse paralysis. With *furious rabies* death occurs in three or four days; with *paralytic rabies*, in about five days.

Symptoms in dogs begin after an incubation period of about fifteen days. 1. *Furious Type:* The dog shows a marked change in disposition, with alternating restlessness, excitement, aggressiveness, and desire for solitude. The appetite for food is lost, the animal eating its excrement and other unusual things. Rapid emaciation occurs, the bark changes in quality, becoming husky or ending in a high plaintive note; there is difficulty in swallowing food, but no special fear of water. In the furious stage the dog runs great distances from his normal neighborhood, biting and snapping at any animal that is encountered. The *secondary paralysis* begins in the hind limbs, and death occurs in four or five days.

2. *Paralytic* or *dumb rabies* is less common. The animal shows the early change in disposition, followed by paralysis. The paralysis first affects the muscles of the jaw, which drops, and then spreads over the body. The paralytic form seldom occurs in humans.

Diagnosis.—The appearance of a strange dog or cat in a neighborhood, showing paralysis, or excitement, difficulty in swallowing, and a desire to bite, suggests rabies. If the dog can safely be confined, it should be watched for the evolution of symptoms. If it dies or is killed, the head and neck, iced and protected from decomposition, should immediately be sent to a laboratory for study. All persons in the area through which a rabid dog has passed should be warned of the danger from domestic animals that may have been bitten. The presence of *Negri bodies* in the central nervous system of the suspected animal is pathognomonic of rabies. They appear four to eight days after inoculation, and may be stained by the Giemsa or other method.

Prognosis.—Sixteen per cent. of bites of rabid dogs are followed by hydrophobia; about 40 per cent. of the bites of rabid wolves; and an intermediate percentage from the domestic cat. Careful cauterization of the wound, especially during the first twelve hours, reduces the danger of infection one-half. If the dog does not develop fatal symptoms within fifteen days, the bite will not cause rabies.

Treatment.—1. *Prophylactic:* (a) Hydrophobia may be eliminated from civilized countries by muzzling the domestic dog and quarantining alien dogs entering the country. Rabies is unknown in Australia, where all dogs are quarantined for six months before admittance. (b) Bites from dogs, or other animals that may be rabid, should promptly be cauterized with fuming nitric acid. (c) A person bitten by a rabid animal, or who has had an abraded surface in contact with the saliva or milk of a rabid animal, should be given the Pasteur prophylactic treatment.

2. *Pasteur Preventive Inoculation.*—A rabbit, subdurally inoculated by the *fixed virus*, is killed when completely paralyzed (about the seventh day), and the spinal cord aseptically removed. The virulence of various cords thus removed is reduced by drying (suspended in bottles over caustic potash) for from three to eight days. The dried cord may be preserved in glycerin for several weeks with little change; or, after being desiccated while frozen, the resulting powder retains its potency, *in vacuo*, for several years. Beginning with the cord that has been dried eight days (in the earlier Pasteur method, fourteen or fifteen days), subcutaneous injections of the emulsified cord are made, usually into the

abdominal wall; at first twice daily and, after the third day, once daily until twenty-one days have elapsed, and until a cord dried only two or three days is finally used. The modified treatment lasts only fourteen days, an injection being given daily. The mortality following the method is less than $\frac{1}{2}$ per cent. As the immunity produced may not last over six to twelve months, the treatment should be repeated for persons who may have been inoculated from rabid animals six months or more after the first treatment. Local redness, tenderness, itching, induration, malaise, numbness, tingling may be noted during the treatment. Very rarely neuritis, paraplegia, or other palsies, which even may be fatal, have followed the treatment. There is so little danger from the injections that they should be given in all cases of possible inoculation through a bite, scratch, or abrasion.

3. With the development of the disease the treatment is *purely palliative*, with the use of sedatives, relaxants, and antispasmodics, until death relieves the unfortunate victim. No effective antitoxin has been developed, and a recovery suggests that an error was made in the diagnosis.

Tularemia (*deer-fly ferer*) is an infectious, inoculable disease, caused by *Bacterium tularense.*

Etiology.—*Bacterium tularense* (McCoy and Chapin, 1912), first discovered in ground squirrels from Tulare County, California, causes a fatal bacteremia of wild rodents, as cotton-tail rabbits, jack rabbits, snow-shoe rabbits, ground squirrels, and rats. It is transmitted to man by inoculation even through the unbroken skin or conjunctival sac, due to handling or skinning infected wild rabbits or other rodents. The bite of an infected, blood-sucking deer fly (*Chrysops discalis*), a horse fly (*Chrysops dispalis*), the wood-tick (Dermacentor andersoni), or the bite of wild or domestic animals that have recently eaten infected rodents also may convey the disease. The bacterium is a small, pleomorphic, Gram-negative, non-motile, non-spore-bearing, aërobic organism having an optimum temperature requirement of 37° C., and a thermal death-point of 56° to 58° C.

Pathology.—Areas of focal necrosis occur, with central caseous zones surrounded by a layer of epithelioid cells and fibroblasts in radial arrangement, and a peripheral zone of lymphocytes (containing a few giant-cells), forming a granuloma closely resembling that of tuberculosis.

Clinical Types.—(1) *Ulceroglandular:* The primary lesion is a papule, followed by a cutaneous ulcer and regional lymphadenopathy. (2) *Oculoglandular:* A conjunctivitis with regional lymphadenopathy, which may be fulminant and fatal. (3) *Glandular:* Local lymphadenopathy without evidence of primary lesion. (4) *Typhoidal:* A bacteremia without primary lesion or glandular enlargement.

Symptoms.—One to nine days (with an average of three days) after skinning or dressing rabbits, or after the insect bite, the patient—usually a market man, cook, hunter, housewife, or laboratory worker—develops a very painful, sensitive, irregular, punched-out ulcer, with raised edges and purulent discharge. The tributary lymphatic nodes, as the epitrochlear and axillary nodes, enlarge. Nausea, vomiting and headache, nosebleed, generalized aching, high temperature, chills, sweating, weakness, convulsions, delirium, prostration, and stupor

with papulopunctate skin eruptions occur. The constitutional symptoms resemble those of typhoid. The initial fever lasts one, two, or three days, with a remission of temperature for one, two, or three days, followed by a second rise to the original height, after which there is a gradual decline to normal, the whole febrile period lasting two or three weeks. Leukocytosis is moderate, rarely exceeding 14,000. The skin eruption is macular, papular, or pustular.

Ulceroglandular Type: The local lymph-nodes become tender and enlarged within forty-eight hours, and twenty-four hours later an inflamed papule appears from which a necrotic core is expelled, leaving a punched-out ulcer with raised edges 1 cm. in diameter. The lymphatic glands and lymph-vessels suppurate (50 per cent.) or remain hard and tender for two or three months. The overlying skin is reddened. Firm, movable subcutaneous nodules ($\frac{1}{2}$ to 1 cm. in diameter), simulating sporotrichosis, appear and may suppurate.

Oculoglandular Type: There is lacrimation, chemosis, edema with papules or small discrete ulcers upon the conjunctiva of both lids; tenderness and pain in the preauricular, parotid, submaxillary, anterior cervical or, in severe cases, even the axillary lymph-nodes. A purulent dacryocystitis occasionally occurs, but perforation of the cornea or impairment of vision is rare.

Diagnosis.—A history of having dissected or dressed a wild rabbit, or having been bitten by a tick or fly; followed by papule and persistent ulcer, or conjunctivitis with persistent lymphoglandular enlargements, and fever of two or three weeks' duration suggest tularemia. The unbroken skin may be penetrated. The *Bacterium tularense* may be isolated from the blood, ulcer, or lymph-nodes. The diagnosis is confirmed by the agglutination test, present after the first week, and the inoculation of guinea-pigs with blood from the patient. The pigs die, with enlarged liver and spleen showing necrotic areas. The surface of the liver of the diseased rabbit shows characteristic, minute white nodules.

Prognosis.—Convalescence is slow, with weakness and prostration which may last from six months to a year. Relapses often occur after several months. The mortality is from 4 to 15 per cent. One attack confers immunity.

Treatment.—*Symptomatic*, with rest in bed and avoidance of work during the remission. Incision or excision of enlarged glands is not advised until suppuration occurs. No preventive vaccine or curative serum has as yet been perfected.

Gangrenous balanitis (*Balanoposthomykosis, fourth venereal disease*) is a destructive and gangrenous type of balanoposthitis in the lesions of which a Gram-negative spirochete is found.

Treatment consists in the early use of solutions of peroxid of hydrogen or permanganate of potassium. Surgical excision or cauterization of necrotic tissue may be required.

CHAPTER XII

CHRONIC SURGICAL INFECTIONS—THE SPECIFIC GRANULOMAS

Granulomas are definite inflammatory and degenerative lesions, caused by specific micro-organisms, and characterized by a tendency to produce masses of modified granulation tissue. Granuloma may produce fibroconnective tissue, as in rhinoscleroma, or may promptly degenerate, as in glanders. Degeneration results from parasitic products and faulty blood-vessel formation.

Tuberculosis.—An inflammatory and degenerative granulomatous affection of man and lower animals, caused by the *Mycobacterium tuberculosis* (*Bacillus tuberculosis, Koch's bacillus, tubercle bacillus*).

Etiology.—The *Mycobacterium tuberculosis* is an aërobic, acid-fast organism, with an average measurement of 2 x 0.035 μ. It has rounded ends, a slight curve, contains a waxy substance, is slightly motile, is peculiarly resistant to stains and decolorizing agents, and has a thermal death-point of 65° C. It occurs singly and in small groups. Its habitat is the tissues of warm- and cold-blooded animals. Precise knowledge of its natural growth outside of the body is wanting. Its growth under artificial cultivation is slow, requiring several weeks for colonies to develop, and necessitates special media, such as glycerin-agar or special blood-serum. Pale gray or yellowish, dry, wrinkled, rather firm, crust-like surface masses are formed by the growth of the bacteria. It grows at a temperature about that of the body in the absence of strong light and in the presence of free oxygen.

The bacillus is detected (a) by inoculating guinea-pigs with some of the suspected material, and six weeks later killing them and searching for the characteristic lesions of tuberculosis; or (b) by staining spread smears of suspected material three minutes with hot carbol-fuchsin, and decolorizing for five minutes with a 3 per cent. solution of hydrochloric acid in absolute alcohol. Tubercle bacilli retain the red fuchsin color after this treatment, while nearly all the other bacteria are decolorized.

The bacillus may enter the body through the respiratory, digestive, or genito-urinary tract, or through injuries and abrasions of the skin, as in butchers, undertakers, dissecting porters (*dissecting porter's wart*). Congenital placental transmission is rare, inherited predisposition common; an inherited or acquired lack of tissue resistance is important.

Pathology.—The *tubercle* is the local area of inflammatory and degenerative reaction caused by the tubercle bacillus, and is the characteristic lesion.

Macroscopy.—Minute (in size from a pin-point to a pin-head), elevated, grayish, firm, embedded nodule on the surface or interior of an organ.

Microscopy.—(1) *Central zone* of coagulation necrosis, which has at its periphery free nuclei and cellular débris ("raked-field appearance"). (2) *Median zone* of epithelioid cells with vesicular, rounded or oval nuclei, often radially arranged, and irregular giant-cells with nuclei arranged (a) along periphery,

(b) at poles, or (c) in an equatorial band. (3) *Peripheral zone* of lymphoid cells. The bacilli are found in the giant-cells, between and in the epithelioid cells and leukocytes, but rarely in the necrotic area.

Progress of Lesion.—(1) Local irritation by the tubercle bacillus. (2) Multiplication of fixed connective-tissue cells (epithelioid cells). (3) Invasion of leukocytes (lymphoid cells) from the blood-vessels. (4) Fusion of epithelioid cells into giant-cells by coagulation necrosis. (5) Destruction of the central cells by coagulation necrosis and fatty degeneration. There is little fibrin formation, and no development of new blood-vessels.

Varieties.—(1) *Gray tubercle*—the early stage. (2) *Yellow*—later stage from fatty degeneration. (3) *Lymphoid*—lymphoid cells predominate. (4) *Reticulated*—bands of connective-tissue fibers, formed by the epithelioid cells or remaining from pre-existent tissue separate the cells into small groups.

Seats.—(1) The *lungs*. (2) The *lymphatic glands*. (3) *Mucous membranes*, especially of ileum and pharynx. (4) *Serous membranes* of joints and pleura, meninges, and peritoneum. (5) The *bones*. (6) *Spleen, kidney, adrenals, brain, genital organs, bladder, skin*. In children the lymph-glands, bones, joints, and meninges, in adults the lungs are most frequently affected.

Extension occurs: (1) *By contiguity*—miliary tubercles tend to enlarge by involving adjacent tissue. (2) *Along natural channels*, as infection of larynx from tuberculosis of bronchi. (3) *Along lymphatics*, through which the bacilli may be carried by the lymph-stream or by leukocytes. (4) *Along blood-vessels*, as an acute miliary tuberculosis from the entrance of tuberculous material into the blood-stream.

Results.—(1) *Recovery*—the bacteria are unable to overcome the tissue resistance. (2) *Encapsulation*—the tubercular area is walled off by newly formed connective tissue, which later may become calcified. If an extensive formation of fibrous tissue occurs, it is termed *fibroid tuberculosis*. (3) *Miliary tuberculosis*—the tubercles form many discrete, minute nodules. (4) *Caseous tuberculosis*—ulcerative tuberculosis, from the fusion of many tuberculous areas with cheesy necrosis. The areas may be encapsulated; or the contents may liquefy and discharge, leaving cavities (*vomicæ*); or be retained, forming *cold abscesses*. (5) *Death* results from the direct involvement of vital organs, the secondary degenerative tissue changes (parenchymatous, fatty, amyloid), or from the toxemia. The local destructive action and general toxemia are frequently intensified by mixed infection by pyogenic organisms.

Varieties of Tuberculosis.—The main varieties are *miliary, caseous, caseo-fibroid*, and *fibroid*. The encapsulated fibroid tubercle is a source of danger, and may later, under conditions of lowered resistance, release contained bacilli and give rise to a general miliary or caseous tuberculosis. *Cold abscesses* usually are tuberculous, and although tubercle bacilli may not be found by staining methods, inoculation in animals produces the disease.

"Scrofula" is an old term, applied to a form of tuberculosis chiefly affecting lymph-glands. *Lupus vulgaris* is a form involving the skin, as is also the *anatomical wart* or *dissecting porter's tubercle*.

Diagnosis.—*Tubercles* are small, round, grayish or yellowish nodules, not vascular, and embedded in and under the surface. *Secondary malignant nodules*

are grayish, vascular, papillary, craggy or irregular nodules which grow out from surfaces, show greater variety in size and shape, and do not undergo caseation.

Tuberculous ulcers result from submucous or subcutaneous cold abscesses. They are shallow, with sharply cut edges and irregular ragged margins, undermined congested edges with *crabapple-jelly nodules*, pulpy granulation tissue at the base, and contain tubercles or caseous foci. There is no induration, the surface being pale and flabby. On mucous surfaces the ulcer may be painful, and usually is secondary to pulmonary tuberculosis.

Ulcerating gummata are painless, the base is formed by a tough yellow slough resembling "wash leather." The edges are sharply cut, undermined, punched-out, and circinate. There is no induration, and the process starts as an oval or round subcutaneous, submucous, intramuscular, or periosteal infiltration. The ulcer is deep and, on healing, leaves a depressed pigmented or white cicatrix.

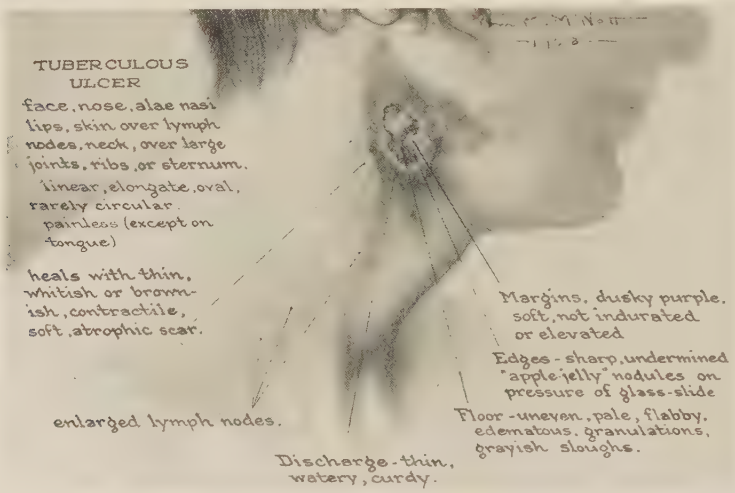

TUBERCULOUS ULCER
face, nose, alae nasi lips, skin over lymph nodes, neck, over large joints, ribs, or sternum.
linear, elongate, oval, rarely circular.
painless (except on tongue)
heals with thin, whitish or brownish, contractile, soft, atrophic scar.
enlarged lymph nodes.
Margins, dusky purple, soft, not indurated or elevated
Edges - sharp, undermined "apple-jelly" nodules on pressure of glass-slide
Floor - uneven, pale, flabby, edematous, granulations, grayish sloughs.
Discharge - thin, watery, curdy.

Fig. 49.—Characteristics of the tuberculous ulcer.

Treatment includes development of general resistance by: (1) *Rest*, local and general, to be continued as long as there is temperature elevation or local activity. (2) *Fresh air* and *abundant nutrition*. (3) *Radiant treatment* by sunlight, ultraviolet or quartz light, Roentgen ray. (4) Stimulation of general resistance by graduated carefully supervised *injections of tuberculin*. (5) *Local Treatment:* (a) Immobilization of affected part. (b) Injection, aspiration, or evacuation of cold abscesses; with prevention of mixed infection, as far as possible. (c) Enucleation of hopelessly diseased organs, such as kidney, spleen, section of intestine or tuberculous areas in bone and soft tissue. If there are open sinuses, the method of zinc-chlorid disinfection with methylene-blue delineation, followed by complete excision and closure, is of value. (d) Excision or incision and open treatment for a mixed infection that cannot otherwise be eradicated, as *fistula in ano*. Iodin, zinc chlorid, bismuth, and iodoform are of some value locally. Nitrate of silver is harmful.

Spironemata or **Spirochætæ** include: 1. Those causing *primary infection*

of the blood or the *spirochetal* fevers, as relapsing fever, African tick-fever, rat-bite fever, leptospirosis, hemorrhagic jaundice, and yellow fever.

2. Those causing *primary local lesions:* (a) The *Spirochæta pallida schaudinni* or *Treponema pallidum*—the spirochete of syphilis. (b) The *Spirochæta pertenuis* (Castellani) -the spirochete of frambesia or yaws. (c) The *Spirochæta schaudinni* (Prowazek)—the organism found in tropical ulcer, pathologically identical with *Spirochæta vincenti* and *Spirochæta refringens.* (d) *Spironema noguchii*, found in dermal granuloma, *Spirochæta calligyra* (cultivated by Noguchi from condylomata), *Spirochæta phagedenas* found in phagedenic lesions of the genitals.

All these infections, except those of yellow fever and hemorrhagic jaundice, are effectively treated by the intravenous injection of arsenicals, particularly *salvarsan, neosalvarsan,* or the *arsphenamins.*

Syphilis.—*Synonyms* are *lues, pox, the specific disease.* It is a chronic, acquired or inherited, general, contagious disease, peculiar to man, but inoculable into certain animals, characterized by (1) a *primary lesion* (*chancre*) at the seat of inoculation, with (2) multiple, superficial, homologous *secondary lesions*—secondary syphilids affecting chiefly the skin (*syphiloderm*), mucous membranes (*mucous patch*), lymphatics (*indolent bubo*) -and (3) deeper, non-homologous, more destructive *tertiary lesions* (*gummata*).

Etiology.—*Treponema pallidum* (Schaudinn and Hoffman, 1905) is a very slender spiral, 4 to 20 μ long, 0.5 μ thick, having three to twelve (or even forty) close, regular turns. It has fine flagella at one end, is flexible, and has a back-and-forward movement with rotation. The organism is killed by drying, and by a temperature of 106° F. (50° to 55° C.) for thirty minutes. In culture it may live one year. From the tertiary lesions—in which the organisms are present in small numbers—infection, although possible, is very unusual. Inoculation usually results from the blood or secretion from a primary or secondary lesion entering an abraded mucous surface (as on the cervix, urethra, vagina, tonsils, tongue) or an open cutaneous surface, especially on the corona glandis, lip, nipple, or finger. Infection occurs as (a) *venereal contamination* in impure coitus; or (b) *accidentally* (*syphilis innocentium*), *directly* as in a surgical operation or examination, or *indirectly* by an infected instrument or utensil—a dental forceps, surgical instrument, drinking-glass. The *chancre* usually appears about three weeks after inoculation, the secondary lesions in six to twelve weeks, the tertiary lesions after two years or more. This course may be modified or atypical.

Pathologic Anatomy.—1. *Primary Lesion:* The chancre begins as a papule or pustule, which soon is transformed into a small, shallow, indolent ulcer with slight secretion, situated upon an elevated, indurated base. Microscopically, there is infiltration of lymphoid cells, epithelioid cells, possibly a few giant-cells, and fluid exudate, with associated endarteritis, lymphangitis, and lymphadenitis. Occasionally a marked adjacent edema is present.

2. *Secondary Lesions:* (a) *Mucous patch*, or *condyloma latum*, occurs upon mucous membranes of the mouth, or the moist, cutaneous areas about the anus or under the breasts, as a broad, macerated and, at times, ulcerated papule with foul, moist, grayish or yellowish surface. Microscopically, there is distention of the papillary layer by serous or leukocytic infiltration, and an infiltration,

swelling, and desquamation of the epithelial layers. (b) *Skin lesions* include macular, papular, vesicular, pustular, and ulcerative *syphilids*. These are usually homologous, rounded, and have a crescentic grouping; histologically they resemble corresponding non-syphilitic lesions. (c) *Iritis*. (d) *Alopecia*. (e) *General lymphadenoid enlargement*.

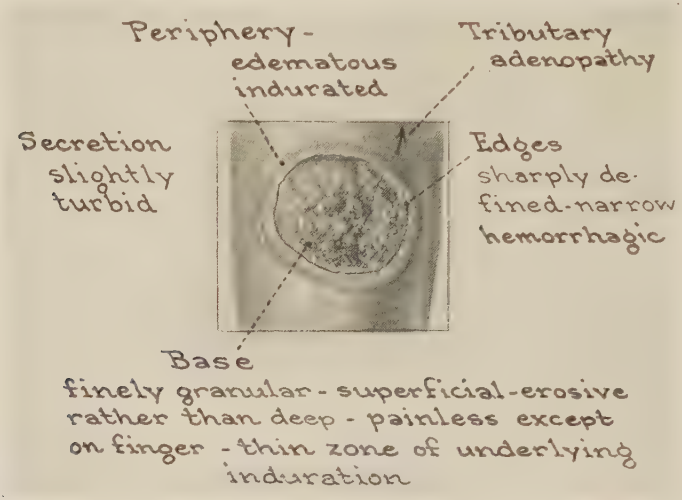

Periphery - edematous indurated
Tributary adenopathy
Secretion slightly turbid
Edges sharply defined-narrow hemorrhagic
Base
finely granular - superficial - erosive rather than deep - painless except on finger - thin zone of underlying induration

Fig. 50.—Characteristics of the chancre.

3. *Tertiary Lesions: Gummata* or *gummy tumors* affect the subcutaneous tissues, periosteum, bones (tibia, sternum, skull), liver, testicle, spleen, brain. They form rounded, soft or firm, grayish or yellowish masses (from $\frac{1}{2}$ to several cm. in diameter) surrounded by an area of new fibroconnective tissue. The mass

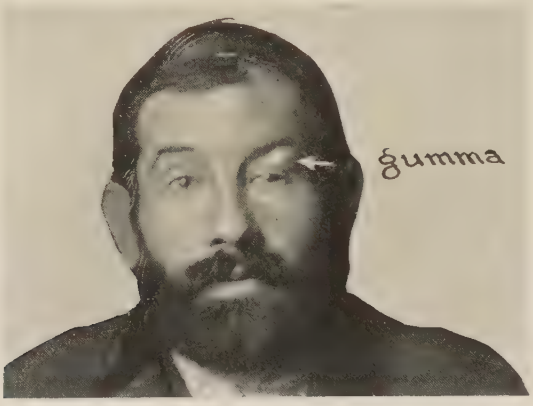


Fig. 51.—Gumma of the supra-orbital ridge which soon disappeared under the administration of iodids and mercurials.

consists of granulation tissue, usually showing mucoid degeneration or central caseous necrosis. Fibroconnective tissue with imperfect new blood-vessels is formed, and a few giant-cells may occur. The associated hyperplastic or obliterative endarteritis favors degenerative changes. Gummata may (a) be

absorbed, (b) *heal*, leaving puckered, thin (tissue paper), striate, depressed pigmented scars, or (c) *soften*, suppurate, and be discharged. In tertiary syphilis there is a tendency to general fibrous hyperplasia in the various organs (*syphilitic cirrhosis* or *sclerosis*, *tabes dorsalis*, *paresis*, etc.).

Syphilitic women usually first abort from lesions in the endometrium, decidua, or placenta. That an apparently healthy mother will not be infected by her begotten syphilitic child (*Colles' law*), or an apparently healthy child be infected by its syphilitic mother (*Profeta's law*), is now recognized as being due to latent syphilis in the one apparently healthy.

Hereditary lesions appear as (a) fibroid induration, enlargement of the liver and spleen, and a characteristic osteochondritis, present at birth, with grayish or yellowish puriform collection at the epiphyseal junction of the long bones.

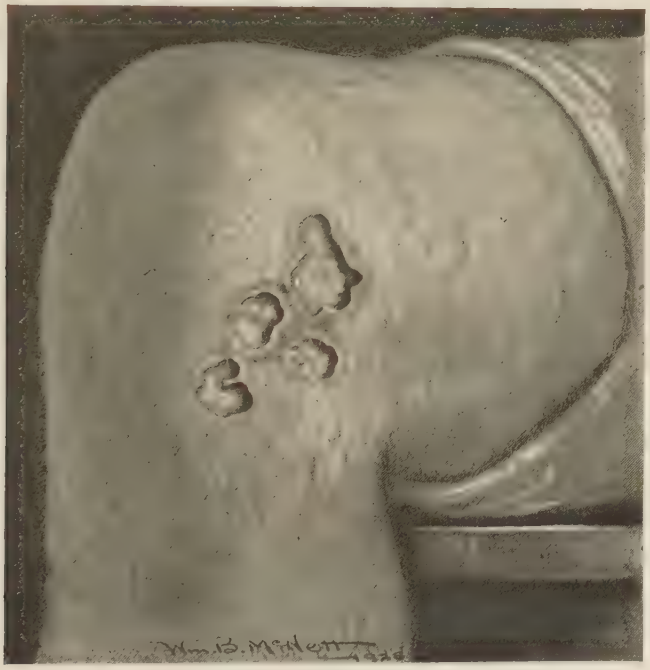


Fig. 52.—Syphilitic ulcers about knee. Note circinate undermined borders.

(b) Rhinitis, snuffles, and pemphigous eruptions about the palms and soles develop four to eight weeks after birth. Fissures, mucous patches, and rhagades occur about the mouth, and pigmented areas and condylomata about the nates.

(c) Delayed and faulty dentition with (1) peg-shaped incisor, thickened anteroposteriorly and converging toward the biting edge without notch (peg tooth), or (2) thick, tapering, notched upper central incisors (*Hutchinson's teeth*), (3) "mulberry" six-year molar (*Fournier's tooth*), or (4) an extra cusp on the lingual surface of the first upper molar (*tubercle of Carabelli*).

(d) Destruction of the bony and cartilaginous framework of the nose, *saddle-nose*.

(e) Gummata of the long bones, occurring about the fifth or sixth year.

(f) *Interstitial keratitis*, or deafness, developing about the time of puberty.
(g) *Syphilitic dactylitis* and *onychia*.

Congenital syphilis is inherited from the mother, and the child with inherited syphilis has an immunity to acquired syphilis until puberty. Hereditary syphilis may be derived from either parent; usually both are infected.

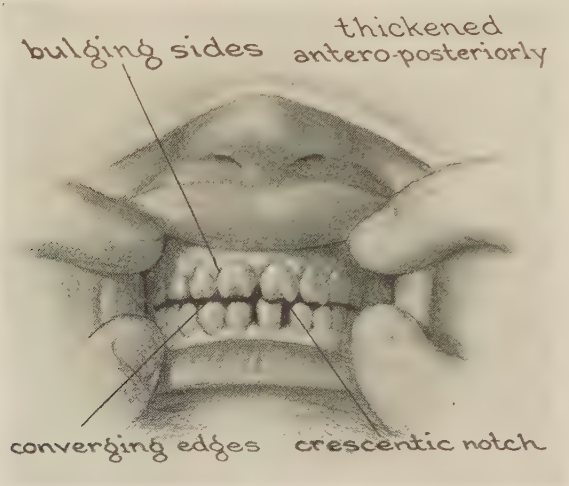


Fig. 53.—Characteristics of Hutchinson's teeth.

Diagnosis is made (1) by finding the characteristic treponema in the lesion, (2) by the presence of a three or four plus Wassermann reaction, (3) by the characteristic lesions, repeated miscarriages, perforation of the palate, nodes on the edge of the tibia.

The lesions differ from tuberculosis in: (1) Absence of tubercle bacilli and presence of treponema, as shown by dark-field illumination. (2) Presence of

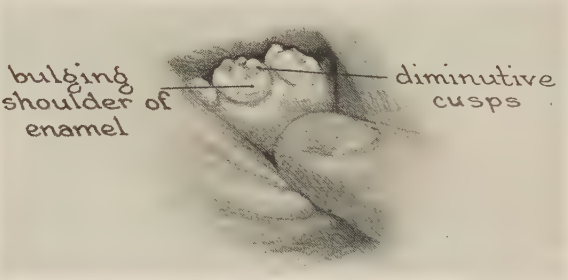


Fig. 54.—Fournier's tooth, a mulberry-shaped six-year molar, also suggests hereditary syphilis.

endarteritis. (3) Scarcity and small size of giant-cells. (4) Vascularization and marked fibroconnective-tissue formation. (5) Tendency to heal with the production of stellate scar and pigmentation. (6) Difference in predilected seat—syphilis is rather rare in lungs and kidneys; tuberculosis is rare in subcutaneous tissues, in the tibia, sternum, palate, nasal and frontal bones. (7) Therapeutic test—tuberculosis usually does not respond to arsenical and mercurial treatment.

Prognosis.—The lesions of syphilis, except those of the central nervous system, can usually be arrested. Absolute eradication of the disease from the body is often impossible.

Prophylaxis.—Physicians and dentists, in their professional work, should avoid conveying or contracting syphilis by sterilizing all instruments before they are used on a patient, by wearing rubber gloves before contacting the hands with mucous or abraded surfaces. An ointment of 33 per cent. of calomel in lanolin (*K. package*), applied soon after inoculation, is a valuable prophylactic.

Treatment should be continued at least two years, and should include the free use of mercury and arsenicals. At least ten intravenous injections of arsphenamin [arsphen, salvarsan] (0.4 to 0.6 gm.) or neo-arsphenamin [neo-arsphen, neosalvarsan] (0.6 to 0.9 gm.) are given at intervals of five to seven days, with weekly injections of mercury. This period of injection treatment should not exceed three months. Under prolonged treatment with insufficient dosage the treponema may become *arsenic-fast* and resist the destructive action of arsenic. After an interval of one month three or four injections of salvarsan and mercury are again given. If, after a delay of six weeks without treatment, the Wassermann reaction continues positive, the entire course should be repeated with the addition of injections of bismuth. In the pregnant woman, arsphen and mercury are continued until one month before labor. After the injection of salvarsan the spirochetes disappear from the local lesions in from twelve to twenty-four hours.

Sulpharsphenamin (sulfarsenol) is an orange-yellow powder, containing not less than 19 per cent. of arsenic, readily soluble in water, less irritating, less toxic, and somewhat more stable than neo-arsphenamin. It is chiefly used for intramuscular injection (0.4 to 0.6 gm.), dissolved in 1.2 to 1.8 c.c. of freshly distilled water. A series of eight injections at intervals of five days are given. It may cause an exfoliative dermatitis or aleukemia hemorrhagica.

Acetylarsan (storarsol) contains about 27 per cent. of arsenic and may be given by mouth in daily dosage of 0.25 gm. per kilogram of body weight. The treatment is continued for five or six weeks with an intermission of three days after each treatment period of four days. In syphilis the treatment should be associated with or followed by injections of bismuth and of mercury. It is useful as a prophylactic, in children, in resistant or Wassermann-fast types of syphilis, and in amebic dysentery and yaws.

Mercurials are used in one or more of the following ways: (1) *By mouth*—0.01 or 0.016 gm. of protiodid, three or four times daily, the dose to be reduced if the gums or teeth become tender. The hygiene of the mouth should be suspended during the treatment to prevent salivation. (2) *Cutaneously*—inunctions of 4 gm. of mercurial ointment, rubbed in for twenty minutes in a new area of the skin daily, for forty inunctions. (3) *Subcutaneously*—intramuscular injections of calomel, gray oil, or salicylate are used. Salicylate of mercury, 0.01 gm., is given subcutaneously or intravenously every two to six days for twenty doses. (4) *Intramuscular injections (insoluble injections)*, Lamkin's mercurial cream—lanolin or gray oil, containing 0.06 gm. of calomel—is injected at blood heat, and

repeated weekly for twelve weeks. The injection is made deep in the buttocks, at the junction of the outer and middle third of a line from the anterosuperior spine of ilium to upper end of intergluteal fold. The needle is introduced to a depth of 3 or 4 cm.

Bismuth injections are valuable, especially if the disease resists treatment, and are made into the deep muscles, as the muscles of the buttock, using potassium tartro-bismuthate, bismuth subiodid, or bismuth subnitrate in olive oil or lanolin. Mineral oil should not be used, as it is retained in the tissues and causes fibrosis.

Twenty weekly intramuscular injections of 100 mg. potassium tartro-bismuthate, combined with eight weekly intravenous injections of 0.4 neo-arsphenamin increased to 0.6 gm., is an approved course of treatment.

Iodids are especially useful in resistant tertiary lesions. The iodid of sodium, potassium, or calcium is given in doses of from 0.5 to 15 gm. three times daily, well diluted. Potassium iodid acts in removing chronic inflammatory tissue, and has no direct action on the spirochetes.

The *danger of infection* is greatest during the first five years of the disease, is slight from tertiary lesions, and is not to be expected from patients with tabes or aortic syphilis. Paternal transmission of syphilis may occur (Hochsinger) without the mother having clinical or serological evidence of the disease.

Treatment of congenital syphilis in infancy: Eight weekly (0.05 to 0.1 gm.) neo-arsphenamin injections given intramuscularly, to be followed by ten or twelve intramuscular injections of mercuric chlorid in oil; or the intramuscular injection of sulpharsphenamin in doses of 0.1 gm., followed by mercurial inunctions or mercury and chalk by mouth. The rectal administration of arsphenamin is not approved.

The *Wassermann reaction* should be repeated after completion of the treatment at intervals of six months until two years have elapsed. For lesions of the central nervous system, as tabes and paresis—which are not benefited by conventional methods, as the treponemicide does not enter the cerebrospinal fluid in effective amounts—the inoculation of malaria may have merit.

Malarial inoculation (Wagner-Jauregg, 1917) has been followed by marked remission in neurosyphilis, especially paresis. The good effect may be due to the temperature elevation of the body produced by the plasmodia (*Thermotherapy*) or other cause. The treponema no longer produces infection after being heated to 104° F. for one hour. It has a thermal death-point of 106° F. for six hours (Schamberg). From malarial inoculation a temperature of 106° F. for six hours or more is not infrequently obtained.

Technic.—From a patient with natural or artificially induced malaria of the tertian type, 2 or 3 c.c. of blood, during any stage, is injected intravenously or, preferably, subcutaneously. After an average of twelve days there is a chill followed by fever and, after eight to sixteen malarial paroxysms, the induced malaria is readily cured by 30 gr. of quinin the first day, followed by 15 gr. daily for six succeeding days, or the disease may be arrested by the intravenous injection of 0.9 gm. of neo-arsphenamin. Reinoculation is at times necessary. For success a temperature over 104° F., persisting six or more hours, is desirable.

Yaws (Framboesia Tropica).—*Synonyms: Pian* (French colonies), *Dubi*

(Gold Coast), *Tetia* (Congo), *Parangi* (Ceylon), *Buena* (Burma), *Coco* (Fiji Islands), *Tonga* (New Caledonia), *Puru* (Malaya), *Boubas* (South America). A highly contagious, generalized, inoculable granulomatous disease, with a raspberry-like (*frambesiform*), crusted, papillomatous eruption due to the *Treponema pertenue* (Castellani, 1905). It resembles syphilis in parasite, in blood reaction, and in having initial, secondary, and tertiary lesions, but is not hereditary or of venereal origin and the lesions are not pleomorphous.

Etiology.—The *Treponema pertenue* is a delicate spiral with 8 to 10 coils, moving with a slow cork-screw motion. It enters the body through an abrasion or wound of the skin, or by the bite of an insect. It is rare in Europeans, and occurs chiefly in natives (especially children) of the lower class, living under unsanitary conditions. It is not congenital, rarely occurs under the age of six months, and is endemic in certain tropical, mountainous regions.

Symptoms.—1. *Primary lesion* develops after an incubation period of from two to four weeks, at the point of inoculation, often about the arms, legs, feet, or mouth, as a papule which becomes crusted and ulcerates. There are associated symptoms of a general infection with headache, arthralgia, fever, and malaise. The primary lesion tends to become granulomatous and persists as the "*mother yaw*" and an adjacent lymphadenopathy is usual.

2. *Secondary eruptive stage* appears about four to six weeks after the primary lesion, with crops of small painless, but itching papules; these desquamate or enlarge, forming soft granulomatous masses with a seropurulent discharge, which dries in yellow or brownish crusts that vary from 0.5 to 2.5 cm. or more in diameter. Lesions occur chiefly upon the face, the extremities, at flexures of joints, about the anus and genitalia, but rarely appear on the scalp. Upon the soles of the feet the lesions ulcerate or form fissures and, by irritation of nerves, cause a crab-like gait (*crab yaws*). From adjacent lesion the nails become opaque, ridged and brittle, and exfoliate. Iritis is rather rare, as is involvement of the mucous membranes. After six or eight weeks the eruption often disappears, leaving whitish or pigmented spots, but recurrences for six months, a year, or longer are not uncommon.

3. *Tertiary lesions* occur years after the disappearance of the eruption, with gummatous nodules on the skin or, less frequently, the mucous membrane of the nose, palate or pharynx, the bones or muscles. The gummatous nodules tend to break down and discharge, leaving ulcers with sharply cut margins and thick undermined edges.

Bones.—Yaws chiefly affects the tibia, radius, and ulna, occasionally the clavicle, ribs, sternum; rarely the skull. Periostitis, osteoperiostitis, osteomyelitis, osteoporosis, or a rarefying osteitis occurs, or localized nodules or a diffuse osteitis may involve the shaft of long bones. Usually there are fibrous nodules on the periosteum. Saber-shaped tibia and dactylitis are quite common. The periostitis may be painful. The epiphyseal involvement in children may interfere with the growth of long bones and cause deformity and shortening.

Joints.—Synovitis, effusion, or infection of the articular surfaces, with fibrous or bony ankylosis, occurs.

Diagnosis from syphilis is made by: (1) the extragenital primary lesion which persists; (2) the peculiar, uniform raspberry eruption instead of multi-

form lesions; (3) the itching (not significant in the negro); (4) absence of hereditary or congenital yaws or (5) involvement of the central nervous system; (6) the possibility of auto-inoculation, and of (7) dual infection with syphilis, against which yaws does not protect.

Histologically, the greatest proliferative change is in the epidermis, with hyperkeratosis and infiltration of plasma-cells, but without the giant-cells, endarteritis, or periarteritis of syphilis. Therapeutically, mercury is useless. On the *skin* the disease simulates *leishmaniasis*, but Leishman-Donovan bodies are absent, and injections of antimony are ineffective. *Verruga peruviana* is similar, but the lesions are hemorrhagic; the disease occurs in the high altitudes of the Andes, and treponema are absent.

Prognosis.—Yaws rapidly disappears after one or two injections of arsphenamin.

Treatment.—Mercury is useless, arsenicals specific for yaws. Antimony is of questionable value, bismuth and iodids of some value. The high temperature from an attack of malaria may be curative. Operative treatment should be resorted to only after a thorough course of arsphenamin or similar drug. Plastic operations are useful for residual deformities and disfigurement. Osteotomy relieves the osteocopic pain. In osteomyelitis—drainage and introduction of bipp or iodoform emulsion are of value.

Rat-bite fever, an infection due to the *Spirochæta* (*spirillum*) *morsus muris* (Futaki, 1915), found in about 3 to 10 per cent. of rats, as well as in mice, cats, weasels, ferrets, and other animals. The disease occurs in nearly every part of the globe, and the animals harboring the spirillum may appear to be free from illness.

Symptoms.—The bite from the rat, cat, ferret, or other animal heals, but, after an incubation period of from ten to twenty-two days, the scar becomes red, swollen, and tender; it ulcerates, and a secondary regional lymphadenopathy occurs, associated with a relapsing fever lasting several days. Often a macular or erythematous eruption appears over the body. Severe pains are present in muscles and joints, and delirium occurs at times. The paroxysms continue for three or four days, and the fever recurs at intervals of two to six days for a number of months, the spleen and, occasionally, the liver enlarging.

Diagnosis.—The organism (a short, thick spiral, usually with five or six short curves) is difficult to find in the blood or tissues of the infected person. The blood of inoculated mice or rats shows the spirillum.

Treatment.—Intravenous injections of *salvarsan* or *neosalvarsan*, in doses such as are used for syphilis, are specific. In rat-bite fever a 33 per cent. calomel ointment is not prophylactic (Fujita), but 40 per cent. of quinin in petrolatum is partially protective if applied five to ten minutes after inoculation.

Chancroid (*soft chancre*) is a local, contagious, non-indurated, spreading, phagedenic ulceration, caused by the *streptobacillus of Ducrey*, usually with an adjacent suppurative lymphadenitis or *bubo*. Chancroid is transmitted by sexual intercourse, and differs from chancre in being auto-inoculable, in tending to spread, to suppurate, and to produce suppurating buboes. It is one-fourth as common as chancre. It is locally very destructive and, by progressive ulceration under a phimosis, may destroy the glans penis and the prepuce.

Treatment.—The ulcer should be freely exposed, if necessary, by a dorsal slit of the prepuce. Circumcision should be avoided, as destructive infection of the wound usually follows.

There should be early evacuation of abscesses, disinfection or cautery destruction of the lesion, and scrupulous cleanliness. Any one of the following methods may be used:

1. *Copper sulphate* and *fulguration method* (Robbins and Seabury): (a) The ulcer is anesthetized by applying a 10 per cent. solution of cocain on a thin layer of cotton for ten minutes. (b) The surface is painted with a 10 per cent. solution of *copper sulphate*. (c) The surface is fulgurated, using a fine electrode and monopolar current until it turns a dirty gray color.

One or several applications may be required, healing on an average occurring within two weeks.

2. *Repeated painting* with Ziehl's carbolfuchsin (fuchsin, 1; alcohol, 10; 5 per cent. phenol solution, 100 parts).

3. *Constant application* of jelly made from a bland sodium (hard) soap and water.

4. *Intravenous injections* of a vaccine made from the streptobacillus have proved of some value.

5. Intravenous injections of tartar emetic is effective in 85 per cent. of the patients (Jones). Three c.c. of a 1 per cent. solution is injected every fourth day, the amount being increased by 1 c.c. at each injection until a mild reaction is produced.

Granuloma Inguinale (McLoed, 1882; Conyers and Daniels, 1896).

Etiology.—An intracellular micro-organism, *Donovan's bodies* (1905). A tropical disease, also occuring in temperate climates, chiefly affecting adult male negroes.

Histologically, a chronic inflammatory process developing in the subcutaneous tissue, with an infiltration by plasma-cells and polymorphonuclear leukocytes. Large, swollen mononuclear cells showing the Gram-negative Donovan bodies by the Romanowsky stain are characteristic.

Symptoms.—The incubation period is indefinite. Three to seven weeks after contact a papule develops on the generative organs or surrounding parts, increases in size, becomes eroded, with milky, thin secretion having a sour, fetid odor which is diagnostic. The granuloma may remain as a single lesion for years, healing in one portion, while spreading in another. Nodules often appear at the site of the first lesion, soon breaking down and often coalescing. The lesions are not essentially painful, but may become sensitive through friction and edema. The regional lymph-nodes are not enlarged. The granuloma projects from the skin, and has an uneven, finely granular surface with scattered hillocks rising above it, some of which are covered by islands of bluish-white epithelium.

Diagnosis.—In *chancroid* there is true ulceration with loss of substance. *Epithelioma* and *tuberculosis* are diagnosed on section. *Syphilis* and *yaws* give a positive Wassermann reaction, and respond to antisyphilitic treatment. The diagnosis is based upon the typical clinical appearance, characteristic odor, the non-enlargement of the regional lymph-nodes, demonstration of the organism in smears, sections, and cultures, the typical pathologic picture on section, and the complement fixation and allergic reaction. The skin test—made by injecting

subcutaneously a saline suspension from a forty-eight-hour culture of the organism, heated two hours at 60° C., and so diluted that 1 c.c. contains 50,000,000 organisms—is followed by a zone of edema and redness and, after twenty-four hours, a hard elevation which lasts for several days.

Treatment.—Intravenous injections of 3 c.c. of a 1 per cent. tartar emetic solution, at intervals of two days, are specific.

Actinomycosis (Lumpy Jaw, Big Jaw, Swelled Head, Wooden Tongue, Clyers, Strahlenpilz [Ger.]).—*Actinomycosis* is a chronic, contagious, inflammatory and degenerative disease of cattle, sheep, and hogs; caused by the *Streptothrix actinomyces* (Bollinger, 1877), and characterized by nodes of granulation tissue, with necrosis, sinus formation, and production of fibroconnective tissue; involving the jaws, tongue, and internal organs.

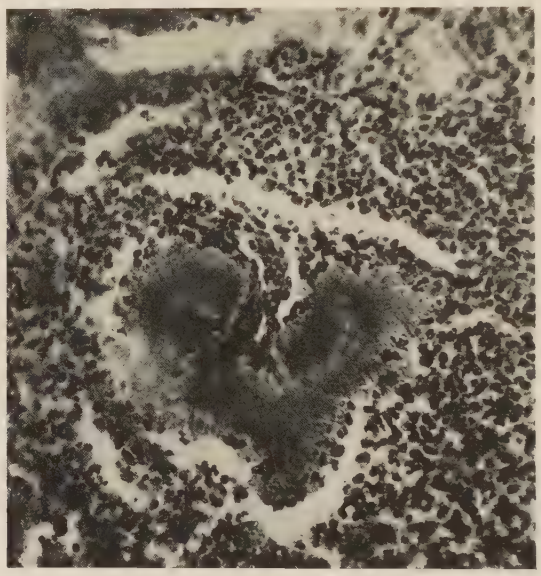


Fig. 55.—The actinomyces or ray-fungus. (From a preparation by Dr. M. Wohl.)

Historical.—Langenbeck saw the sulphur grains in 1845; Bollinger, in 1877, recognized their parasitic nature in *lumpy jaw;* Israel, in 1878, recognized the disease in man.

Etiology.—The *Streptothrix actinomyces* or *ray-fungus* forms minute yellowish or grayish grains ("sulphur granules"), found in the center of the nodes or in discharged pus. Under the low power these resemble chestnut burs, consisting of a center of rounded, spore-like bodies from which radiate branching filaments, peripherally showing club-shaped (involution) forms. The fungus is Gram-positive and resists drying. It does not produce toxemia or lymphatic metastasis, the effects being chiefly local.

Infection follows inoculation from infected animals, from meat, hides, and other animal products, in about 50 per cent. of the patients; butchers, stock- and cattle-men, and handlers of hides often being infected. Infection also occurs from grain, grasses, weeds, and bark, held in the mouth or brought in

ontact with open wounds, or inhaled, as in threshing. Carious teeth may con-ain the organism, and a bite be followed by infection. Eighty per cent. of the atients are males, 50 per cent. coming from the rural districts. Infection ccurs at all ages, from twenty-eight days to eighty-two years of life, and it ccurs chiefly through the mouth. In the United States the disease is prevalent n the upper Mississippi Valley and the Northwest (Sanford).

Varieties.—According to the virulence of the fungus and the patient's re-istance, actinomycosis may be *acute*, *subacute*, or *chronic;* lasting from a few weeks to fifteen, twenty, or more years.

Site.—(1) *Head* and *neck* are involved in 60 per cent., the disease affecting the jaws, neck, and temporofacial region. (2) *Abdomen* is involved in 18 per cent., the abdominal wall, the cavity of the abdomen, the intestines, appendix, or liver being affected. (3) *Thorax* is involved in 14 per cent., the disease being found in the chest wall, lungs, ribs, vertebræ, or mediastinum. (4) Infrequently the *subcutaneous* and *cutaneous tissues*, the *extremities*, the *pelvic organs*, the *periosteum*, or the *central nervous system* are affected. (5) The condition is *rare in bones;* it may become generalized and affect nearly any part of the body, but is almost unknown in the esophagus and the lacrimal duct. It may enter *carious teeth* with secondary toothache, and the extraction of the teeth may be followed by the spread of the disease in the jaws.

Fig. 56.—Actinomycosis of the right cheek. Mr. B., age twenty-five, mail carrier. Scratched right side of face by tall weeds on his route. Two weeks later the face became swollen and painful. The swelling extended to submaxillary region, with formation of two discharging sinuses. Smears from the discharge showed branching filaments, crushed granules showed clubs. Sections of bits of tissue showed necrosis and ray-fungi. Under potassium iodid internally, incision, irrigation with Dakin's solution, and exposure to the Roentgen ray the condition disappeared in six weeks (Dr. M. Wohl).

In head-and-neck actinomycosis, chronic unilateral swellings of the jaw, neck, and cheek develop with induration, secondary softening, abscess and fistula formation, and the discharge of thin grayish or yellowish pus, containing small grayish or yellowish granules formed of the streptothrix.

In the tongue, a rough isolated nodule (1 to $1\frac{1}{2}$ cm. in diameter) occurs about the tip or dorsum, and secondary infection and abscess formation may follow. If acute, there is severe pain. The usual picture of a nodular diffuse mass, with indefinitely outlined induration and multiple sinuses, is rare with the tongue. The process is largely regenerative, and much new fibroconnective tissue is produced (*wooden tongue*). Dissemination by the respiratory, digestive, and circulatory system leads to a form of bronchopneumonia, and production of nodules in other organs.

Abdominal actinomycosis involves the appendix, cecum, and adjacent large intestine. Indurated masses, abscesses, and fistulæ form between the intestinal coils and attach to the abdominal wall, to retroperitoneal, retrocecal, and perirectal tissues, or even to the esophagus.

Pulmonary Actinomycosis: The lung is involved, with symptoms suggesting a chronic bronchitis, miliary tuberculosis, bronchiectasis, fibrosis, a small localized empyema, or necrosis of the ribs. There is a fetid bronchitis with a tendency to involve the pleura, ribs, sternum, and thoracic wall, with abscesses and fistulæ. Pyrexia, cough, wasting, expectoration, and unilateral physical signs are present; metastasis may occur to the liver (with the characteristic honey-comb appearance and contained pus), to the brain (with cerebral abscess), and to the skin and kidneys.

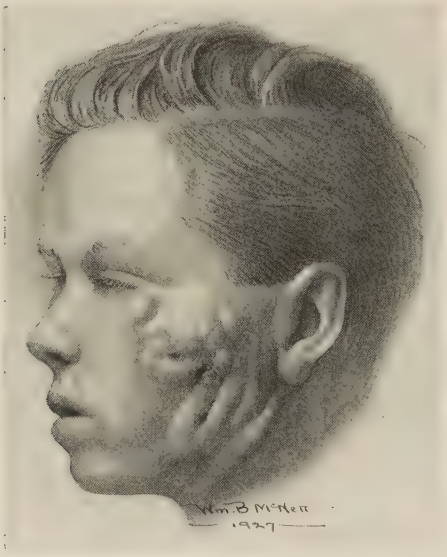


Fig. 57.—Actinomycosis of the face with sinuses.

Diagnosis is made by finding the characteristic streptothrix under the microscope.

Prognosis.—The course is essentially chronic, but if the process is localized, recovery may follow proper treatment. There is a tendency to metastasis and the development of chronic pyemia. Recurrence is frequent after apparent cure. Freedom from symptoms for two years indicates a cure. The pulmonary form is usually fatal. The head-and-neck type gives a mortality of 50 per cent.; abdominal actinomycosis, a mortality of 20 per cent.

Treatment.—Surgical and medical, with potassium iodid in large doses internally, and Roentgen treatment of the lesion. The radiation should be interrupted for ten days every two weeks to permit the more resistant spores to turn into less resistant forms. Copper sulphate and nitrate of silver are useful locally. Surgical extirpation or erasion is often of value.

Glanders (Malleus Humidus, Maliasmus, Farcy, Morve, Farcin [Fr.], **Rotz** [Ger.]).—An acute or chronic, infectious and contagious degenerative inflammatory disease of horses and asses, transmissible to man, caused by the *Bacillus mallei* (Löffler and Shütz, 1882), and characterized by suppurating nodules on the mucous membranes, in the subcutaneous tissues, and in internal organs.

Bacillus Mallei.—A non-motile, non-sporing bacillus (shorter and thicker than the tubercle bacillus), which stains irregularly, is decolorized by Gram's method, and produces a characteristic honey-like growth upon potato, soon turning reddish brown. Man, sheep, goats, young dogs, cats, rabbits, guinea-pigs, and field mice are susceptible; cattle, house mice, white mice, and white rats are immune. Infection usually occurs through mucous membranes or

abrasions of the skin, and is disseminated through the lymphatics and the circulatory, respiratory, and digestive systems.

Seats.—(1) *Mucous membranes*—ulcers occur especially on the schneiderian membrane (*glanders*). (2) *Skin*—subcutaneous tissues and lymphatics (*farcy*). Secondary lesions occur in lymphatics, lungs, about joints, in the gastro-intestinal tract, and other organs. In man the process is, at times, pyemic, and associated with a general pustular eruption of the skin.

Pathology. *Macroscopy.* The grayish nodes (*farcy buds*) develop with a surrounding area of marked inflammation and lymphangitis, and a tendency to rapid necrosis and suppuration, producing deep excavated ulcers, discharging blood-stained, virulent pus. The ulcers tend to spread, but may at times heal, leaving a puckered scar.

Microscopy.—A central area of necrosis with marked leukocytic infiltration and, perhaps, some epithelioid cells. There are no giant-cells, and but a feeble attempt at vascularization. The bacilli enter the human body through the nasal mucous membrane or abrasions of the skin, from association with diseased animals or from infection in a laboratory.

Symptoms.—1. *Acute Glanders.*—The incubation period is from one to five days. The onset is marked by malaise; redness, swelling, and lymphangitis at the site of inoculation; increased temperature and pulse-rate. The constitutional symptoms develop in two or three days, with eruption of papules that soon become pustular, especially on the face and joints. Ulcerating nodules with necrosis and foul discharge appear on the nasal mucosa, the nose becoming very swollen and red. Subcutaneous and muscular abscesses and phlegmons, with associated high fever, may develop within forty-eight hours. Bronchitis and pneumonia occur from foci in the lungs, followed by a typhoid state, marked intestinal symptoms, acute septicemia and collapse. Death occurs usually in eight to fourteen days. The mortality is 95 per cent. The lymphatic glands and testes usually are not affected.

2. *Chronic Glanders.*—The incubation period is ten or more days, the duration of illness many months, with recovery of 50 per cent. The initial rash may be papular, pustular, or erysipelatous. The characteristic symptom is the formation of abscesses in the subcutaneous and intramuscular tissues, especially near the joints. These rupture, leaving an irregular ulcer with offensive discharge which may heal and relapse. The disease may continue in a mild or latent form for years, and a fatal relapse finally occur. The nose and lungs usually escape.

Diagnosis.—The bacilli are found in the discharges and, at times, in the blood-culture. Intraperitoneal injection of guinea-pigs results in a characteristic suppuration of the testes in two or three days. *Mallein* is used like tuberculin to confirm the diagnosis in animals.

Treatment.—For acute cases, isolation and symptomatic treatment. In chronic cases it is advisable to open and drain the abscesses and use sodium benzoate and the vaccine (*mallein*).

Lepra (leprosy, elephantiasis græcorum) is a chronic, progressive, inflammatory disease, caused by the *Bacillus lepræ* (Hansen and Neisser, 1879), and characterized by nodules in the skin, subcutaneous tissues, internal organs (*lepra nodosa*), and in the nerves (*lepra anæsthetica*).

Etiology.—The *Bacillus lepræ* of Hansen resembles the tubercle bacillus in morphology and staining, but is not curved, is more readily stained, and occurs in clumps in the tissues. Attempts at cultivation and inoculation have usually been unsuccessful.

Geographical Distribution.—China, India, Syria, Sandwich Islands, Scandinavia, West Indies, Gulf Coast. It is prevalent along the coasts of tropical countries.

Pathologic Anatomy.—*Lepra Nodosa.*—Hyperemia, followed by nodular masses, involves the skin of the face, flexor surfaces of the feet and hands, and extensor surfaces of the knees and elbows. The lymphatics, liver, spleen, testicles, and other internal organs are also affected. The associated lesions of the lungs, kidneys, and intestines are thought to be usually tuberculous. The nodes are yellowish or grayish, of irregular size, and may ulcerate or cicatrize, producing hideous distortion. They consist of newly formed connective tissue and contain blood-vessels, leukocytes, epithelioid cells, and lepra-cells. The lepra-cells may be multinuclear, but tend to become anuclear, and distended by vacuoles containing clumps of the bacilli. There is no caseation. A general lymphatic enlargement may occur.

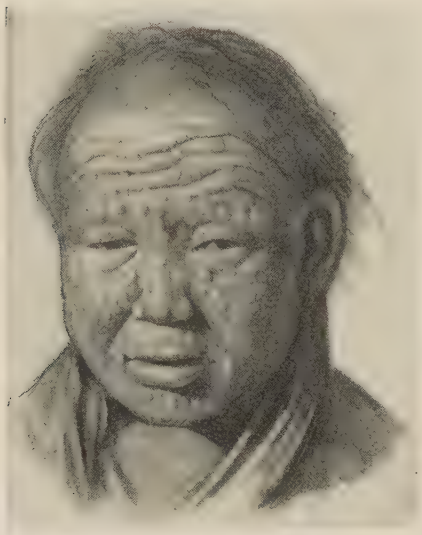


Fig. 58.—Nodular leprosy. Note thickening of the skin-folds and coarse frontal wrinkles. (Patient of Dr. B. M. Harding.)

Lesions of *lepra nodosa* (*lepra tuberosa, tuberculosa*) include macules, nodes (*lepromes*), fissures, ulcers and, at times, alopecia from involvement of the hair-follicles. The nodose and anesthetic form often coexist.

Lepra anæsthetica (*lepra nervosa*) is characterized by cylindrical or fusiform swellings upon the nerves (especially the ulnar and popliteal), by whitish or brownish spots, bullæ and scales on the skin, and by hyperesthesia followed by anesthesia, favoring destructive ulceration, and loss of fingers, toes, and other parts (*lepra mutilans*).

Leprosy is moderately contagious. Transmission has been ascribed to direct contact (as sexual intercourse), to fomites, and to bites of insects. The incubation period is many months. Death often occurs from intercurrent affections in from five to twenty years. Ulceration is favored by the anesthesia, diminished trophic innervation, external injury, and mixed infection.

Treatment.—Fresh air, overfeeding, persistent full doses of chaulmoogra oil (doses of 1 c.c. thrice daily) or, better, *ethyl chaulmoograte* (*chaulmestrol*), the dose of which is 1 to 5 c.c. after each meal. Weekly deep intramuscular injections are preferred, beginning with 1 c.c. and increasing every second or third injection until 3 to 5 c.c. are given at a time. This treatment, persistently used, is apparently curative.

Mycetoma (Madura Mycosis, Madura Foot, Pied de Madura, Fungus-foot of India, Podelkoma).—A chronic, local, infectious, inflammatory disease caused by the *Actinomyces streptothrix* or *Actinomyces maduræ* (Vincent, 1894), and characterized by the development—usually on the plantar surface of the foot or palm of the hand—of slow-forming inflammatory nodes (*buttons*) tending to degenerate and rupture, forming sinuses with foul serosanguineous discharge. The poorly nourished natives of India are chiefly infected, often by the prick of a thorn. The nodes, at first dark and congested, later become soft from degenerative changes. All structures, including bone, cartilage, and joints, are involved. The fungus masses in the discharged pus appear as (a) dark (black) "gun-powder grains" (*dark* or *melanoid mycetoma*), or (b) light, pale, "salmon-roe grains" (*pale mycetoma*).

Pathology.—There is a central area of necrosis with branching threads of fungus, surrounded by vascularized granulation tissue. The micro-organism is aërobic, does not liquefy gelatin, is Gram-positive, and has no effect when injected into lower animals. It resists drying for months, but the hyphæ and spores are killed in three minutes at 83° C. Giant-cells are rare. The course is usually painless, and suppuration may not occur for several months.

Treatment.—Excision or amputation. Potassium iodid is useless; Roentgen-ray or radium treatment with the intravenous injections of antimony, and local radiation may be of some value and should be tried.

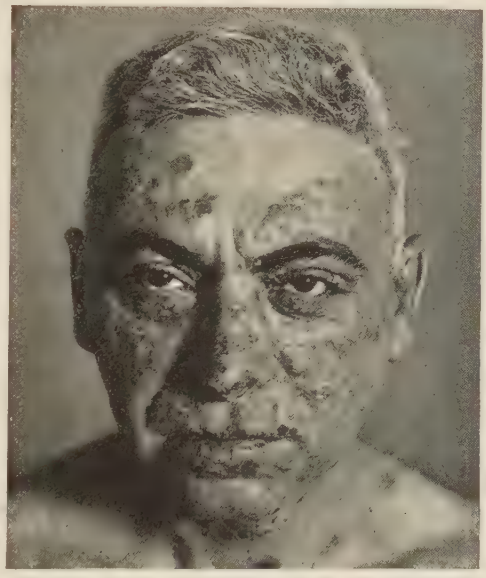


Fig. 59. Mycosis fungoides, resembling leprosy and papular infiltrative syphilis (Fordyce and Wise).

Granuloma Fungoides (Mycosis Fungoides; Inflammatory Fungoid Neoplasm; Lymphadenie Cutanée; Multiple Sarcoma (?) of the Skin).—A chronic granulomatous disease, probably of parasitic origin, characterized by irregular, reddish, smooth, scaly or crusted, eczema-like areas upon the skin, followed by the development of soft, reddish nodules and fungoid tumors. These masses may spread, may suddenly disappear, leaving only a pigmented spot, and reappear; may weep watery and bloody fluid from abrasion, or may slowly ulcerate. Lymphatic enlargements and, in rare cases, secondary nodules in the viscera occur. The disease progresses to marasmus and death from complicating conditions in from six to fifteen years (average three to six years). Animal inoculations have failed.

Treatment.—Symptomatic. Radiation locally, and arsenicals subcutaneously or intravenously should be tried.

Rhinoscleroma.—A chronic, progressive, productive disease caused by the

Bacillus rhinoscleromatus (Frisch, 1882), and characterized by flattened or diffuse, firm, nodular swellings of the skin or mucous membranes of the nose, palate, pharynx, or larynx, which may extend to lacrimal ducts, lip, trachea, and other parts. It is found in Austria, Italy, Hungary, parts of Russia, and Brazil. The affected skin surface shows scales and superficial fissures and, at times, slight ulceration; the color is dark or unaltered. The masses consist of granulation and fibroconnective tissue, with cells that contain vacuoles or hyaline masses enclosing bacilli. The bacillus has a capsule, grows in ordinary media, stains by Gram's method, and resembles Friedländer's pneumobacillus. The growths tend to progress and to recur after excision.

The *treatment* is usually unsatisfactory. Radiation and arsenicals should be tried.

Goundou (Gros-nez, henpuys, dog nose, anakhré, big nose, horned men) (Macalister, 1882) is endemic in West Africa, Malaya, West Indies, Sumatra, China, and other tropical countries, and is characterized by firm, symmetrical bony swellings situated on either side of the nose, due to a proliferative chronic periostitis with hyperostosis and fibrous thickening. It occurs chiefly in men, and in certain of the anthropoid apes. A parasitic cause, as the penetration of the periosteum by the larvæ of flies, has been suspected, but not proved.

Symptoms usually begin in childhood or early youth with frontal headache and pain in the nose, followed by a bloody serous nasal discharge and, after some months, a gradual swelling on either side of the nose over the nasal portions of the superior maxillæ, with some respiratory obstruction and deformity. The eyes are at times displaced by pressure. The mucosa and overlying skin are not involved, but similar overgrowths occur upon the tibia and other long bones. The hyperplasia may slowly progress, or be arrested about the time of puberty.

Diagnosis is made by the symmetrical, bilateral, chronic bony overgrowth, from gangosa (*pseudogoundou*) and the subperiosteal gumma of tertiary syphilis.

Treatment.—Goundou is refractory to all known forms of medical treatment, but the deformity may be permanently relieved by a careful subperiosteal resection of the bone. For the hyperostosis of the long bones, operative treatment is less satisfactory.

Blastomycosis (Blastomycetic dermatitis, oïdiomycosis, Saccharomycosis hominis) (Gilchrist, 1896) is an infection by a pathogenic yeast, usually with a warty eruption on the skin resembling *lupus vulgaris*, or occasionally abscesses in the lungs, kidneys, liver, spleen, muscles, and bones, and a tendency to death from pyemia. It occurs chiefly in men of the poorer class, between seventeen and fifty-eight years of age, with lowered general resistance. The yeast may enter through a wound or abrasion of the respiratory tract.

1. *Cutaneous Type.*—Blastomycetic dermatitis is characterized by multiple verrucose patches, chiefly upon the face, legs, hands and back, with reddish-brown nodules, crusts, and miliary abscesses having a foul, penetrating, nauseating stench. Secondary retrogression occurs, with the formation of red, shiny parchment-like scar-tissue. The disease spreads by auto-inoculation. Fever, pain, and local tenderness are present, but, as a rule, there is little effect upon the general health or enlargement of the tributary lymphatics.

2. *Systemic blastomycosis*, characterized by the formation of abscesses in

the internal organs, is often confused with tuberculosis of the lungs, kidneys, or intestines, or with pyemia. Involvement of the lungs causes irregular fever, leukocytosis, wasting, cough, night-sweats, blood-stained expectoration, dyspnea, fever; and, from involvement of the larynx, hoarseness. Diarrhea is produced by the enteric infection; albuminuria and pyuria with casts, by invasion of the kidney. A chronic involvement of the larger joints may suggest rheumatism. Small or large abscesses may be formed in the internal organs, muscles, joints, and bones.

Diagnosis is made by finding the yeast in the pus, blood, sputum, or other secretions. Slide preparations should be made with 5 per cent. *liquor potassiæ*.

Prognosis.—(1) Cutaneous blastomycosis is chronic, but tends to slowly retrogress and to disappear under proper treatment, although occasionally a

Fig. 60.—Blastomycosis of the leg following scratch of the leg, duration six months. Mrs. M., aged forty-two, farm worker. The area of the scratch became swollen and painful. Many small abscesses formed at the edges of the lesion in which blastomyces were found. The application of copper sulphate locally and the use of large doses of potassium iodid internally were followed by healing in two months. (Dr. C. McMartin and Dr. M. Wohl.)

fatal systemic extension occurs. (2) Systemic blastomycosis is usually fatal after a number of weeks or months.

Treatment should include hygienic care and ample diet for the undernourished patient. Precipitated copper sulphate, 0.016 to 0.18 gm., mixed with sugar of milk is given three times daily (Bevan), and 1 gm. of potassium iodid three times daily. The medication is discontinued for three days every fifth day. If the disease is resistant, the iodid should be increased to 15 or 20 gm. daily. Injections of from 2 to 6 gm. of sodium iodid with 1 or 2 gm. of sodium cacodylate may be given intravenously.

Local Treatment.—After removing crusts and cleansing the affected areas, compresses wet with 1 per cent. copper sulphate should be continuously applied. For very chronic resistant lesions, Jackson cooks the tissues with a

soldering iron or other cautery to a depth of 3 or 4 mm. This is followed by curetting, with a sharp spoon-curette, and recauterization until all evidence of the disease is destroyed. The cautery should leave a lightly charred, seared surface. The copper lotion is then applied. Skin-grafting is, occasionally, desirable after the infection has been eradicated.

Sporotrichosis is a dermatomycosis due to *Sporothrix shenkii*, which usually enters the body through an abrasion or prick upon the hand. Painless nodules occur along the lymphatics, soften and discharge seromucoid pus, which contains the oval spores with budding processes. Gumma-like masses and cold abscesses may also involve the bones, joints, tendons, and other tissues.

Treatment.—Local application of solutions of iodin, with large doses of iodids internally.

Oriental Sore (Cutaneous or Dermal Leishmaniasis, Delhi Boil, or Bagdad Boil, Biskra Button, Aleppo Boil, Kandahar Sore, Lahore Sore).—An indolent, ulcerating, inoculable and auto-inoculable granuloma due to the *Leishmania tropica*, affecting the skin and mucocutaneous surfaces, occurring in Northwestern India, in Arabia, Persia, Mesopotamia, Sudan, the countries bordering on the Mediterranean, and occasionally in Ceylon. The aurinasal

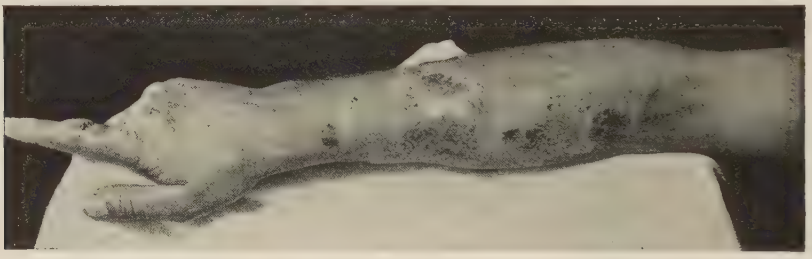


Fig. 61.—Typical sporotrichosis from cutaneous inoculation on the index-finger. The disease extends along the lymphatics. Cultures are best obtained from the softened nodules before they discharge (Stokes).

variety is common in South America and Mexico, and affects the external ear; in Persia the sore occurs in dogs.

Etiology.—Inoculation occurs through the bite of an insect or direct inoculation of the protozoön. Recent residents in the tropics are especially predisposed. *Leishmania tropica* grows in the endothelial cells of the corium. The epidermis, sweat-glands, sebaceous glands, or hair-follicles are not primarily affected. A rounded, incrusted, almost painless ulcer occurs, with a granulating base and profuse purulent discharge. An ulcer (*Oriental sore*) may appear on the mucous membranes as the primary lesion is healing, and invade the hard and soft palate, gums, and labial mucosa, destroying soft tissues and cartilages, but rarely involving the bone.

Symptoms.—After an incubation period of several weeks or months (average two months), a small macule appears, usually on an exposed part of the skin, which becomes indurated, nodular, crusted, and forms an irregular, chronic, painless ulcer, 1 to 3 cm. in diameter, with eroded edges, thickened borders, unhealthy granular base, and seropurulent secretion. The lymphatics are not

involved, except through a mixed infection. The ulcer persists for months, may spread, and heals with a whitish depressed scar. Multiple lesions are not uncommon, and verrucokeloid forms and papillomatous varieties resembling frambesial granulomata occur. Leishmania have been found in the appendix. The Wassermann reaction is usually negative.

Diagnosis is confirmed by finding the parasites in the discharge and scrapings. Oriental sore is distinguished from blastomycosis, tertiary and late secondary syphilis, tuberculosis, and frambesia by the chronic course and the demonstration of *Leishmania tropica.*

Prognosis.—Marked cachexia, and death from intercurrent disease is common.

Prophylaxis.—Screening from insects. Tincture of iodin or other antiseptic should be applied to all bites.

Treatment.—Intravenous injections of 5 to 10 c.c. of a 1 per cent. solution of tartar emetic are specific. The local treatment is cleanliness and the application of bismuth subiodid or methylene-blue. Chlorin or potassium permanganate solutions and a dusting-powder of 1 per cent. tartar emetic in chalk are useful. Radiation and diathermy are of value. Operative treatment is rarely required, although cauterization is at times beneficial.

Espundia (Leishmaniasis, mucocutaneous leishmaniasis, aurinasal leishmaniasis, aurinasal pharyngeal leishmaniasis, Breda's disease, Uta, Bouba Braziliana, American Leishmaniasis), a form of oriental sore due to the *Leishmania tropica* (American variety), is endemic in South America (especially in Peru and Brazil) and, rarely, in Asia, Ceylon, and India. Infection is conveyed by direct contact or by blood-sucking insects.

Pathology.—The nodules show a marked proliferation of plasma and endothelial cells, and marked endarteritis. The lesions are not very vascular, and secondary fibrosis, necrosis, and ulceration are usual.

Symptoms.—*Primary lesion*, a nodule which develops after an uncertain period of incubation, ulcerates, and is followed by ulcerating granulomas of the cartilaginous portion of the nasal septum. The nose is deformed, an edematous swelling appears below the eyes, ulceration may extend to the larynx, affecting phonation. The ulcers are fetid and chronic, and secondary malignancy may occur.

Treatment.—Antimony, or as for other forms of leishmaniasis.

Tropical Phagedena, Tropical Ulcer (Ulcus Tropicum, Naga Sore, Cachar Sore, Annamite Sore, Mozambique Sore, Aden Ulcer, Yemen Ulcer, Malabar Ulcer).—A chronic auto-inoculable ulcerating granuloma, chiefly affecting the legs, with tendency to slough and become phagedenic, occurring in tropical and subtropical regions of Africa, Asia, and America. It may be carried by infected flies.

Etiology.—Spirochetes (*Spirochæta schaudinni*) and fusiform bacilli in symbiosis are usually found in the granulation tissue, with evidence of a secondary pyogenic infection. It is less frequent where there is a free supply of fresh vegetables and fish.

Symptoms.—A painful papilloma appears, surrounded by an infiltrated red area, followed by necrosis, and ulceration. The ulcer has concave base, a foul grayish false membrane, and a phagedenic spread to deeper tissues may occur.

The course is chronic, the ulcer finally healing with a disfiguring scar which may break down on slight injury.

Diagnosis should be made from frambesia, phagedena, syphilis, tuberculosis, and mycosis, by the character of the lesion and examination of the discharge, tissue, and blood. Oriental sore is smaller than tropical ulcer, less destructive, without inherent tendency to phagedena, and from it Leishman bodies may be isolated.

Treatment.—Intravenous injections of arsenicals and antimony may be of value. Locally cauterization or curettage to remove the false membrane and sloughing tissue, and the application of iodin, iodoform, potassium permanganate, or copper sulphate are of value. In the primary aseptic stage, excision is followed by rapid healing. The hygienic care and ample nourishment of the patient is very important.

Gangosa (Rhinopharyngitis Mutilans, Kaninloma [Fiji]) is a destructive ulceration of the nasopharynx and soft palate, with nasal catarrh, cellular infiltration, formation of vascular granulomatous nodules which coalesce, ulcerate, and become necrotic.

Fig. 62.—Deformity of face and loss of eyes from gangosa.

Etiology.—Tropics, where it occurs in natives rather than Europeans, especially Guam, Ladronne Islands, Fiji, Caroline Islands, British Guinea, Panama, and Italy. The causal micro-organisms have not been definitely shown.

Symptoms.—Coryza, snuffles, followed by the appearance of nodules on the pharyngeal mucous membrane, which ulcerate, give off an offensive odor, and spread, destroying the soft tissues, cartilage and bone, converting the nasal and oral cavities into one large space. It may spread to the eyes or larynx. Ulcers may appear in other parts of the body. Secondary cicatrization, contraction, and stenosis may follow. The Wassermann reaction is positive in certain patients. The condition resembles yaws. There is little impairment of the general health.

Diagnosis should be made from syphilis, yaws, and tuberculosis by the absence of the specific organism, the distribution and character of the lesion, and the resistance to treatment.

Treatment is unsatisfactory. Intravenous injection of arsenicals, local cleanliness, bismuth powders and paste may be tried. Permanganate injections reduce the odor. Mercury and iodids are of limited value. Plastic operations are usually ineffective.

CHAPTER XIII

TUMORS AND CYSTS

TUMORS

Synonyms.—New growths, neoplasms, pseudoplasms.

Definition.—A tumor is a functionless new growth, resulting from a progressive and frequently harmful hyperplasia or metaplasia of tissues belonging to the organism. "A mass of tissue of new formation, tending to persist or increase" (Cornil and Ranvier). "An autonomous new growth of tissue" (Ewing).

Characteristics.—Tumors (1) consist of tissues resembling in type those normally found in the organism; (2) are new formations that always alter the normal structure of the part; (3) are independent of normal laws of development; (4) are not the result of ordinary inflammatory conditions; (5) are useless, practically functionless, and always harmful; (6) tend to increase and persist; (7) are liable to retrogressive, degenerative, or inflammatory changes.

Tumors may be (1) *histoid*—of the type of simple tissues, as a lipoma or fibroma; (2) *organoid*—of the type of an organ, as an adenoma; (3) *teratoid*—of mixed type, as a teratoma.

Tumors are (1) *homologous* or *homoplastic*, resembling the tissue in which they grow, or (2) *heterologous* or *heteroplastic*, dissimilar to the tissue in which they grow.

Vascularization.—Tumors have an independent vascular system, and the *blood-vessels* may be (1) unusual in arrangement (plexiform); (2) greatly increased in number (telangiectatic) or in size (cavernous); (3) deficient in number, favoring degenerative changes, as in lipoma, fibroma; or (4) with imperfect walls, favoring extravasation, hemorrhages, and metastases, as in sarcoma. *Lymphatics* are present, and may be plexiform, enlarged, or increased in number. Tumor extension may occur through the lymph-channels, as in carcinoma, or through the blood-vessels, as in sarcoma.

Innervation is usually imperfect.

Function.—Useless. At times there is an imperfect attempt to imitate the function of the tissue prototype; thus acromegaly or giantism may follow the growth of tumors of the pituitary gland; hyperthyroidism, adenomas of the thyroid; precocious development, tumors of the adrenal glands; and an imperfect milk secretion may occur in tumors of the mammary gland.

Growth is independent of the normal growth and development of the organism, or is without the organogenetic influence. The growth is: (1) *Central* or *expansive*, the adjacent parts being displaced as in benign tumors; (2) *peripheral* or *infiltrative*, the surrounding tissues being invaded, as in malignant tumors; or (3) by *metaplasia*, with the transformation of adjacent tissue into neoplastic tissue. Rapidity of growth varies, usually being greater in malignant tumors.

Varieties.—(1) *Primary tumor*, the first occurrence of a type of tumor in the organism. (2) *Secondary* or *metastatic tumor*, one dependent upon the preexistence of a primary tumor, and having a different seat. (3) *Recurrent tumor*,

one recurring in the same site after removal. (4) *Simple benign* or *benignant tumor*, one without inherent tendency to a fatal issue. (5) *Malign* or *malignant tumor*, has an inherent tendency to a fatal issue. The *signs of malignancy* are: (a) Recurrence *in loco* after excision (*recidivity*); (b) invasion and destruction of adjacent tissue, or *local infiltration;* (c) metastasis; (d) cachexia.

A tumor may be well circumscribed and encapsulated, as are most benign tumors; or infiltrating, non-encapsulated, and non-circumscribed, as are most malignant tumors.

Metastasis is the transference of a morbid process from one portion of the body to another, usually occurring through the vascular or lymphatic channels, and inducing secondary lesions having the characteristics of the primary disease.

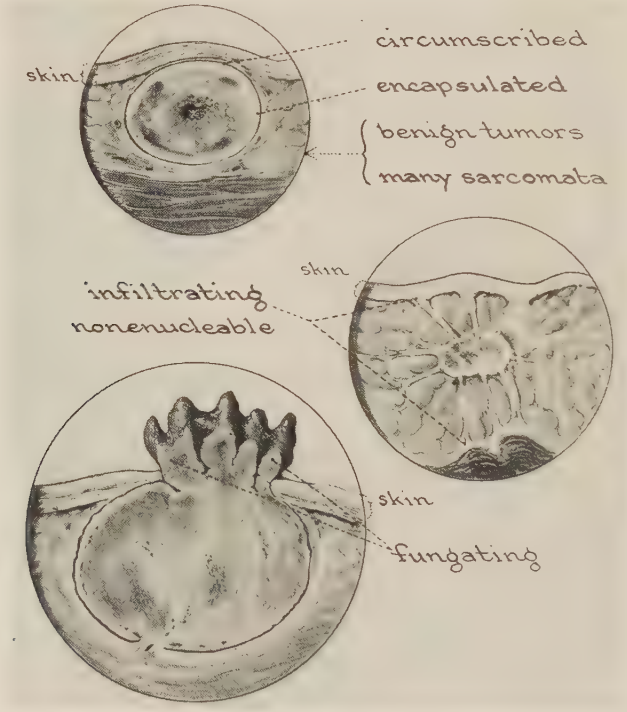


Fig 63.—Circumscribed, infiltrating, and ulcerating (fungating) tumors.

Malignant tumors—as the sarcomas, carcinomas, and endotheliomas—are prone to metastasize.

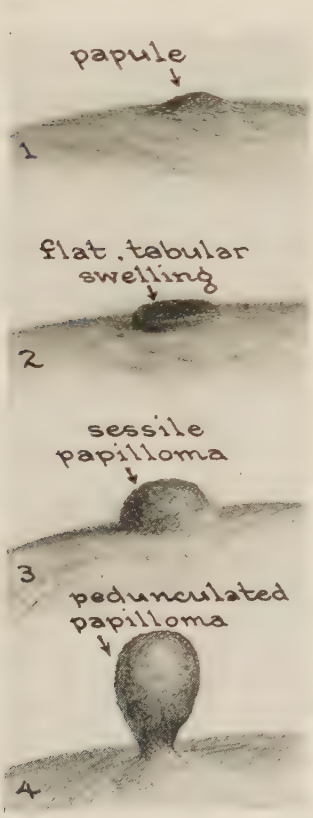
Degenerative changes are frequent in tumors, and include fatty, pigmentary, calcareous, mucoid, and colloid degeneration, inflammation, ulceration, necrosis, and gangrene.

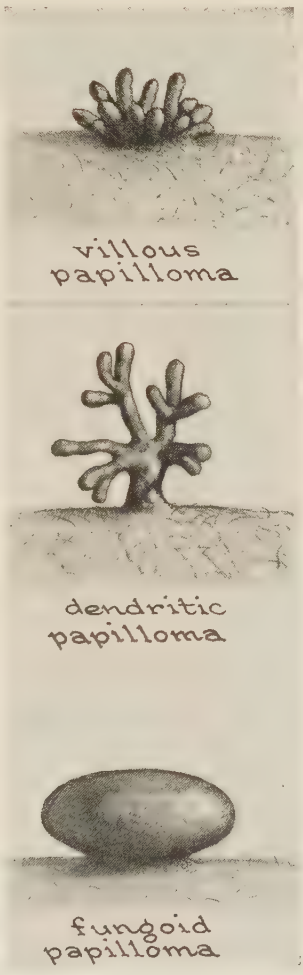
Combinations between different tumors of the same blastodermic parentage are frequent. Tumors of different blastodermic origins are rarely transmutable, although one may be invaded by the other.

Morphology.—(1) *Flat tabular swelling* (*condyloma latum*)—a broad, slightly elevated area. (2) *Node*—a rounded elevation. (3) *Polyp*—a pediculated or

pedunculated growth. (4) *Fungoid mass*—a large projecting portion overhangs the base. (5) *Dendritic*—cauliflower or coral shaped. (6) *Papillary*—villous, verrucose, or warty.

Etiology.—A. *Predisposing factors:* (1) *Age*—sarcomas are more common under thirty; carcinomas are rare under thirty-five. (2) *Sex*—tumors are more frequent in women than in men; with exceptions, as carcinoma of the stomach, which is more frequent in men. (3) *Heredity*—a predisposition to tumors may be transmitted, but true heredity is questionable. Congenital tumors occur rarely. (4) *Irritation* (the mechanical theory of Virchow) seems often to predispose, *e. g.*, epithelioma of the scrotum in chimney-sweeps, carcinoma





Figs. 64, 65.—Morphology of surface tumors.

of the lips in inveterate clay-pipe smokers, carcinoma of the gall-bladder in association with gall-stones. (5) *Environment* and *mode of life*—carcinomas seem more common in certain localities and in meat-eating animals.

B. *Exciting cause:* (1) *Parasitic theory*—bacteria, protozoa, blastomycetes, ultramicroscopic organisms have repeatedly been claimed to be the cause of malignant tumors, especially carcinoma, but in no instance has a causal rela-

tionship been proved. The recent ingenious theory of Gye has not been confirmed. (2) *Theory of embryonic remains* (*Cohnheim's theory*) is that embryonic cells, misplaced or retained in the body, proliferate, forming tumors. (3) *Nervous theory*—abnormalities of trophic innervation of a part stimulate local tissue overgrowth and tumor formation.

Diagnosis.—From inflammatory swellings, tumors are differentiated by: (1) Permanence of structure. (2) The various types of tissue reproduced. Inflammation leads only to the formation of fibroconnective tissue. (3) Leukocytes are not essential cell elements. (4) Inflammation is an effort to eliminate a source of irritation. The cause of tumor formation is obscure. Contrasted with normal organs, tumor growth is unlimited, atypical, irregular, the tissue produced is never precisely like normal tissue, and there is no useful function.

Prognosis.—Tumors persist, except in rare cases in which they are extruded, destroyed by degenerative changes, or absorbed. Malignant tumors tend to a fatal result. Recidivity probably occurs from an incomplete excision. Complete excision before metastasis has occurred should be followed by recovery. Death from tumors may be produced by: (1) *Invasion of or pressure upon a vital organ*, thus, death may result from a benign tumor pressing upon the medulla or obstructing the trachea. (2) *Absorption of poisonous products* from metabolic activities in tumors, or their bacterial invasion and degeneration. (3) *Hemorrhage*, which may be profuse and repeated, as in uterine fibromyoma, carcinoma, and fungating sarcoma. (4) *Exhaustion*, from nutriment diverted by the tumor, degeneration, prolonged suppuration, and the like.

Histologic Classification of Tumors

I. *Connective-tissue tumors.*

A. Fibroblastoma.

1. Fibroma { hard. / soft.

2. Multiple fibromas of nerves.

3. Growths related to fibroma { fibrosis. / keloid. / xanthoma. / nasal polypus. / elephantiasis.

4. Giant-cell tumors { epulis. / giant-cell tumor of bone.

5. { Fibrosarcoma. / Undifferentiated sarcoma { spindle-cell. / mixed or polymorphous. / round-cell.

6. Psammoma.

B. Myxoblastoma { myxoma. / myxosarcoma. / lipomyxoma.

C. Chondroblastoma { enchondrosis. / enchondroma. / chondrosarcoma. / multiple cartilaginous exostoses.

D. Osteoblastoma { true osteoma. / hyperplasias resembling osteoma { osteophyte. / exostosis. / myositis ossificans. / osteosarcoma.

I. *Connective-tissue tumors:*
- E. Lipoblastoma { lipoma. / liposarcoma.
- F. Chordoma.

II. *Angioblastoma.*
- A. Hemangioma { nevus vinosus. / hemangioma simplex. / hemangioma cavernosum. / hemangio-endothelioma.
- B. Lymphangioma { lymphangioma simplex. / lymphangioma cavernosum. / lymphangioma cysticum (hygroma).

III. *Myoblastoma.*
- A. Leiomyoma.
- B. Rhabdomyoma.

IV. *Tumors of the Blood-forming Tissues.*
- A. Lymphoma.
- B. Lymphosarcoma.
- C. Multiple myeloma.

V. *Melanoblastoma.*
- A. Nevus pigmentosis.
- B. Malignant melanoma (melanosarcoma).

VI. *Tumors of Nervous Tissue.*
- A. Glioma.
- B. Neuro-epithelioma.
- C. Ganglioneuroma.

VII. *Epithelial Tumors.*
- A. Papilloma.
- B. Adenoma.
- C. Odontoma.
- D. Carcinoma.
  1. Epidermoid carcinoma.
  2. Glandular carcinoma.
     - a. On histologic structure { adenocarcinoma / carcinoma simplex. / diffuse infiltrating carcinoma. / gelatinous carcinoma.
     - b. On gross structure { scirrhous. / medullary. / gelatinous (colloid).
  3. Special forms of epithelial tumors.
     - a. Dental tumors { odontoma (meaning calcified type) / dentigerous cyst. / adamantinoma.
     - b. Renal tumors.
     - c. Thymoma.
     - d. Chorio-epithelioma.

VIII. *Mixed Tumors.*
- A. Mixed tumors of salivary glands.
- B. Mixed tumors of the kidney.
- C. Mixed tumors of the testes.

IX. *Teratoma.*

Fibroma.—Definition.—Benign tumor of the type of fibroconnective tissue.

Varieties.—(1) *Hard fibroma*, hard fibroid or desmoid tumor. (2) *Soft fibroma.*

Seat.—Subcutaneous and submucous tissues, peripheral nerves, fasciæ, tendons, periosteum, uterus, mammary glands, and ovaries.

Pathology.—(1) *Hard fibroma* forms a rounded, nodular, bosselated, or at times pedunculated tumor, well circumscribed or encapsulated, firm, with glistening, whitish surface, on section showing curling striæ. (2) *Soft fibroma* is rounded, circumscribed, at times pedunculated; grayish-white, soft, with moist section, and less distinct striæ. The *hard fibroma* consists of compactly arranged fibers of adult connective tissue with a few spindle-cells. The *soft fibroma* is more cellular and has a more open structure; the cells are stellate or spindle shaped; the softness may be due to edema or to mucoid degeneration. Fibromas are not, as a rule, very vascular, but cavernous, telangiectatic, or hemorrhagic changes may occur.

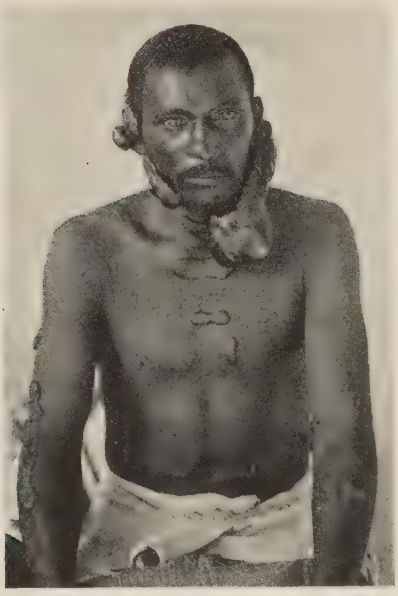


Fig. 66.—Keloids following traumatism (Dr. William N. Parkinson).

Fig. 67.—Fibroma molluscum (Drs. William N. Parkinson and J. S. Fanz).

Combinations occur with myoma, myxoma, lipoma, and sarcoma. Degenerations are calcareous, fatty, and mucoid. Edema and necrosis often result from the imperfect blood-supply.

Clinical Features.—Fibromas are benign. In the uterus they may produce severe metrorrhagia, and may be extruded or destroyed by necrosis. Fibrous epulis and fibrous nasal and pharyngeal polyps tend to recur if not completely excised.

1. *In the Uterus:* (a) Subperitoneal, (b) Interstitial or intramural, (c) Submucous.

2. *Keloid:* A fibrous, tumor-like growth developing from cicatrices, usually in negroes.

3. *False Neuroma:* Small, usually painful, fibrous tumors occurring as multiple nodules along the course of small nerves, or as bulbous enlargements of the divided ends of nerves (*amputation neuromas*). The latter are inflammatory and not true tumors.

4. *Painful Subcutaneous Tubercles:* Small, very painful subcutaneous fibromas growing from nerve endings.

5. *Adenofibroma:* Fibroma growing in association with certain glands, as the mammary. The new growth may surround the glandular ducts or acini (*pericanalicular fibroma*), or project into the lumen and greatly distort the ducts and acini (*intracanalicular fibroma*).

6. *Fibroma Molluscum, Dermatolysis, Fibrocellular Tumor:* Multiple soft fibromas of the skin, originating from the corium or subcutaneous tissues, and forming flattened nodes, pendulous or tabulous folds, or pedunculated masses, which may cover a large area of the surface of the body.

7. *Papillomatous Fibroma:* Certain warts, in which the papillary overgrowth predominates over the epithelial hyperplasia, may be classed with the fibromas.

8. *Elephantiasis, Elephantiasis Arabum, Pachyderma:* A massive overgrowth involving the fibroconnective tissue of the skin, subcutaneous tissue, blood- and lymph-vessels; with associated muscular degeneration and atrophy, affecting the leg (*elephant leg, Barbados leg*), scrotum (*lymph scrotum*), and labia. It usually develops from repeated attacks of inflammation following lymphatic obstruction by filaria or other agent, and is not a true tumor formation.

9. *Fibrous Epulis:* A fibrous tumor of the gums (at times showing lymphangiectasis) which may recur after excision. Usually it is due to local irritation.

10. *Fibrous polyps* occur in the nose, pharynx, intestinal tract, uterus, and bladder.

Comparative Pathology.—Fibromas are not uncommon in the subcutaneous and submucous tissues of the lower vertebrate animals, including fishes. Rarely, a melanotic benign variety occurs in horses.

Treatment.—*Enucleation* or *excision.* When producing pressure upon the brain, a *decompression operation* may give symptomatic relief. If the tumor continues to grow, however, the symptoms recur. In the uterus a percentage of fibromas are reduced in size by Roentgen or radium radiation or after the the menopause or a bilateral oöphorectomy.

Giant-cell Tumor.—Formerly confused with myeloma, myeloid sarcoma, malignant epulis (when growing from the jaws). *Giant-cell tumors* (relatively benign) have been separated from the sarcomas, chiefly by the efforts of Bloodgood. They usually arise from the medulla of the upper end of the tibia, the lower end of the radius, or the maxillary bone. They are to be distinguished from mixed-cell sarcomas, which may contain giant-cells. The giant-cell tumor is soft and dark red, resembles bone-marrow, and contains many giant-

cells with a faintly granular protoplasm and a group of nuclei near the center of the cell. The tumor is vascular, and was formerly classed with a group of fungoid bleeding growths—the *fungi hematoides* of the older surgeons. It produces little pain, but weakens the bone and predisposes to spontaneous fracture. The invasion of the cortex of the bone, or adjacent articular cartilage, is slow. The tumors do not metastasize and, when thoroughly destroyed or removed, do not recur. *Partial removal* may be followed by continued growth.

Diagnosis.—The roentgenogram shows a rounded area of decreased density usually at the epiphyseal end of a long bone, usually without invasion of the cortex or articular cartilage.

Treatment.—*Complete excision* or *thorough curettage*, followed by the application of zinc chlorid or the cautery, to destroy any residual cells, and closure. Amputation is only necessary to reduce disability or deformity.

Myxoma.—A benign tumor of the type of mucous tissue.

Seat.—Subcutaneous, submucous, subserous tissues, the intestine, peritoneum, bone-marrow and periosteum, the brain, cord and peripheral nerves, intermuscular septa, and interstitial tissue of glands, especially of the mammary and parotid glands.

Pathology.—A rounded, lobulated, circumscribed or encapsulated, pale grayish or reddish, translucent, soft, semifluctuating tumor, with moist surfaces on section, exuding mucilaginous fluid. The consistence varies with the number of cells. Some forms are very soft and translucent (*myxoma gelatinosum* or *molle*), others are somewhat firmer and more opaque from the greater number of cells (*myxoma medullare*). The tumor may be embedded, sessile, or pedunculated, as the myxomatous polyps of the nose or uterus.

Microscopy.—Small spindle- or stellate cells with long, delicate, anastomosing processes, widely separated by masses of clear homogeneous mucus. As a rule, the tumor is not very vascular.

Myxomas rarely occur except in combination with other fibroblastomas, as lipoma, sarcoma, chondroma, or fibroma.

Degeneration.—Cyst formation occurs from complete mucous degeneration, fatty degeneration, hemorrhage, necrosis, ulceration, cavernous and telangiectatic changes.

Comparative Pathology.—Myxomas are rare in the lower animals.

Varieties.—1. *Intracanalicular myxoma* often occurs in the mammary gland. A diffuse bilateral myxoma or fibroma of the breast has improperly been termed "hypertrophy of the breast."

2. *Hydatidiform mole* (*uterine hydatid*) grows from the chorionic villi, and forms in the uterus a villous tumor which may invade or perforate the uterine wall.

3. *Mucous polyps* are common in the nose.

Clinical Features.—Myxomas, usually benign, may be malignant, and recur after removal. The hydatidiform mole shows malignancy by the tendency to recur or to perforate the uterus. It may cause severe hemorrhage. Myxomatous tissue in tumors of bone indicates malignancy.

Treatment.—Operative *enucleation* or *excision*. Mucous polyps may be removed by snare or knife, and the base from which they spring should be

cauterized to prevent their recurrence. For hydatidiform mole, *hysterectomy* is desirable.

Chondroma.—A tumor having the characteristics of cartilage. **Varieties:** *Fibrous* and *hyaline chondroma*. *Enchondroses* are projecting outgrowths, usually springing from the larynx, the articular, the costal, or the intervertebral cartilages. Loose cartilages in joints originate from detached chondrified synovial fringes, and are not true tumors.

Seat.—Periosteum and medullary cavity of long bones, especially the phalanges of the hands and feet, the lower end of the femur, the upper end of the humerus, tibia, and rarely the ribs, pelvis, intermuscular septa, and subcutaneous tissue. *Mixed tumors* containing cartilage occur in the parotid, submaxillary or lacrimal gland, the testicle or ovary.

True chondromas rarely grow from cartilage.

Pathology.—Pale, translucent, circumscribed, encapsulated, rounded lobular masses which are hard unless softened by mucoid change. They are often multiple. The *cells* resemble those of normal cartilage, but show variations in size, shape, and grouping. They may be rounded, fusiform, or stellate, occur singly or in groups and, in places, the capsule or cell wall is indistinguishable. The matrix may be hyaline, fibrous, or myxomatous.

Chondromas frequently occur in rickety animals, including the birds and lizards.

Combinations. A chondroma is often combined with a myxoma, osteoma, or sarcoma.

Degeneration. Myxomatous and fatty degeneration, cyst formation, calcification, ossification.

Clinical Features. Chondromas, usually classed as benign, occasionally show malignant tendencies, and from bone may give metastasis to the lung. Chondromas are of slow growth, unless combined with a rapidly growing tumor, as sarcoma. They may be congenital, or often are associated with rickets.

Treatment.—Excision may be difficult, especially of the chondromas growing from the phalanges of the hands and feet. They are firmly embedded in, and produce more or less destruction of, the bones from which they grow, and are extensive and multiple. Chondromas are not amenable to radiation.

Osteoma.—A benign tumor of the type of osseous tissue, resulting from the ossification of newly formed connective tissue of non-inflammatory origin.

Varieties. *Exostosis* grows from the surface of bone; *enostosis*, in the medullary cavity (rare).

1. Compact or ivory osteoma (*osteoma durum* or *eburneum*).
2. Cancellous or spongy osteoma (*osteoma spongiosum* or *medullare*).

Bony outgrowths of inflammatory origin are also termed "exostoses"; diffuse bony outgrowths, "hyperostoses"; and localized or dendritic outgrowths, "osteophytes."

Seat.—(1) *Homologous osteoma* occurs on the external or internal surface of the skull, jaws, scapula, pelvis, epiphyseal junctions, and tendinous insertions of long bone; (2) movable—*periosteal osteoma;* (3) *parosteal osteoma* situated near bones; (4) *disconnected osteoma*, in tendons and muscles; (5) *heterologous osteoma* occurs in the meninges, lung, diaphragm, parotid glands, and skin.

Pathology.—Smooth, rounded, lobulated or irregular, sessile or, more rarely, pedunculated, well-encapsulated bony growths. On serous membranes, as the *falx cerebri*, they may appear as flat plates. In microscopic section they resemble hard or cancellous bone. Haversian systems are present, but are less regularly arranged than in normal bone.

Combinations occur with chondroma, sarcoma, fibroma, and lipoma.

Degeneration: Inflammation, caries, and necrosis.

Related overgrowths which are not true tumors: (1) *Myositis ossificans*, a progressive ossification (in children) of connective tissue, in and between muscles. Localized ossification of muscle also occurs from horse-back riding (*rider's bone*), gun-carrying (*drill bone*), etc., and may require excision. (2) *Hypertrophic pulmonary osteo-arthropathy*, and enlargement of the bones of the hands, feet, forearm, and leg (especially the terminal phalanges) due to an *ossifying periostitis*, occur in pulmonary tuberculosis, bronchiectasis, and other chronic diseases of the chest. (3) *Leontiasis ossea*, a disease characterized by enlargement of the bones of the skull and face. (4) In *acromegaly* the enlargement involves the bones of the hands, feet, and face. (5) In *Paget's disease* there is an enormous bony overgrowth of the skull, with changes in the long bones and spine.

Comparative Pathology.—Osteomas occur in nearly all vertebrates, especially on the skull and jaws of the ungulata. The *spavin* of horses is of inflammatory origin.

Clinical Features.—Osteomas are benign, of very slow growth, may be multiple, and, when congenital, are usually symmetrical.

Treatment.—*Surgical removal* by chisel, gouge, rongeur, saw, or burr driven by surgical engine. The *osteoma durum* may have such density as to make removal very difficult. Osteomas are removed to relieve pain, to restore function, or to overcome deformity. They may press upon important structures, as the eye or nerves, or interfere with the normal movements of joints, muscles, and tendons. Not only the bony tumor but also the base from which it springs should be removed to prevent recurrence.

Neuroma.—A benign tumor of the type of nerve-tissue.

Varieties.—*True neuroma* (rare); *false neuroma*, fibroma, myxoma, gumma, etc., growing from nerves.

1. *Ganglionar neuroma*, consisting of ganglion-cells and fibers.

2. *Fibrillar neuroma*, consisting of fibers which may be medullated or myelinic, or non-medullated or amyelinic.

3. *Plexiform or Cirsoid Neuroma.*—The nerve-fibers are increased in number, show nodular thickening from myxomatous and fibromatous change, and are twisted, convoluted, or intertwined. They usually appear as subcutaneous tumors, and often in connection with hairy moles.

4. *Amputation Neuroma.*—A bulbous, fibrous enlargement at the ends of divided nerves, which may contain convoluted nerve-fibers and cause much pain.

Seat.—Cranial and spinal nerves, especially the peripheral portions.

Pathology.—*Microscopy:* Small, hard, fusiform or nodular masses. The nerve-fibers are usually intermixed with fibroconnective tissue.

Combinations: Fibroma, myxoma, sarcoma.

Clinical features are benign, may be congenital or hereditary, rarely acquire a large size, and seldom occur in the lower animals.

Treatment.—*Excision* if painful or disfiguring.

Glioma.—A tumor composed of neurogliar tissue. As glia-cells are of ectodermic origin, this is not a true connective-tissue tumor.

Seat.—Brain, eye, and spinal cord. Gliomas are twenty times more frequent in the brain than in the cord.

Pathology.—An ill-defined, non-encapsulated mass, usually embedded in and resembling cerebral substance; either darker, firmer, and more vascular than the white matter, or occasionally pale, translucent, and soft. Sections show glia-cells with a large rounded nucleus, a small amount of protoplasm, and many delicate, interlacing, projecting processes (spider-cells). Multinuclear cells may be present. The cells of the intervening stroma may preponderate. The tumor is vascular.

Combinations: Fibroma, myxoma, neuroma, and sarcoma. The so-called gliomas of the eye usually spring from the retina, and are found to be sarcomatous.

Degenerations: Calcareous, myxomatous, fatty, telangiectatic, hemorrhagic, and cystic.

Clinical Features.—Glioma of the retina is very malignant; of the brain and cord, usually malignant; certain gliomas do not recur or metastasize, although dangerous because of their seat.

Gliosis.—A diffuse, rather nodular, neurogliar hyperplasia, usually occurring near the cavities of the brain and cord, and frequently associated with cyst formation.

Neuroglioma ganglionare is an ill-defined tumor resulting from the hyperplasia of ganglion-cells and nerve-fibers, and probably due to faulty embryonic development.

Treatment.—Early complete excision if possible.

Myoma.—A benign tumor of the type of muscle.

Varieties.—(1) *Leiomyoma, myoma lævicellulare*, of the type of unstriped muscle. (2) *Rhabdomyoma, myoma striocellulare*, of the type of striped muscle.

Leiomyoma.—*Seat:* Uterus, esophagus, stomach, intestine, ovary, prostate, testicle, subcutaneous tissue.

Pathology.—Rounded, nodular, encapsulated, sessile or pedunculated, reddish or grayish, soft or firm tumor, showing, upon section, whirls of fibers. It is softer, darker, and usually more vascular than a fibroma.

Microscopic sections show bundles of fusiform cells containing rounded nuclei; cross-sections of cells show rounded nuclei, surrounded by a rim of protoplasm. The tumor usually contains a considerable proportion of fibro-connective tissue (fibromyoma).

Combinations: Fibroma, myxoma, sarcoma.

Degenerations: Calcareous, myxomatous, fatty necrosis, gangrene. Contained blood- or lymph-vessels may become telangiectatic. Hemorrhage and cyst formation occur.

Comparative Pathology.—Rare in lower animals, but have been noticed springing from the internal generative organs of mares, cows, bitches, and monkeys.

Clinical Features.—Leiomyomas are often multiple, and may be congenital; are benign, but in the uterus may lead to serious hemorrhage, dystocia, and

sepsis, and in the intestine may cause obstruction of the bowel. Uterine myomas may be subperitoneal, interstitial, or submucous.

Rhabdomyoma.—Pure striped-muscle tumors are almost unknown, but spindle-shaped or elongated cells showing transverse and, at times, longitudinal striation (more rarely fully developed muscle-fibers) are found in certain spindle-celled sarcomas, mixed tumors of the kidney, intestine, ovaries, uterus, and prostate. The sarcolemma is usually imperfect.

Circumscribed masses of striped muscles have been found in the heart, usually congenital and, from sarcomatous association, malignant. Metastases are not common.

Treatment.—Excision or enucleation.

Lipoma.—A benign tumor of the type of adipose tissue.

Seat.—(1) *Subcutaneous tissues*, especially about the shoulder, back of chest, supraclavicular region, arm, hip, thigh, buttocks. (2) *Subserous tissues*, as in the mesentery, omentum, and under

Fig. 68.—Excised lipoma of the scapular region showing lobulated outline.

Fig. 69.—Diffuse lipomatosis of the upper half of the body. In this patient the lipomas did not extend below the elbows or waist.

the peritoneum (*properitoneal lipoma*). These may enter hernial openings (*fatty hernia*). (3) *Subsynovial lipomas* may form large numbers of pedunculated tumors projecting into joints (*lipoma arborescens*). (4) *Submucous tissues* of the intestinal tract, conjunctiva, larynx. (5) *Muscles* within the intermuscular septa, including the voluntary muscles and the cardiac septum. (6) The *spinal dura*, extra- or intra-dural lipomas, may be associated with *spina bifida* or *nerve sheaths* (*neurolipoma*).

Pathology.—Rounded, lobulated, encapsulated, sessile or pendulous, soft, semifluctuating tumor; of yellowish, greasy section, showing narrow bands of

fibroconnective tissue. In subcutaneous lipomas these bands are attached to the overlying integument, producing dimpling when the skin is raised.

A *microscopic section* is almost identical with that of ordinary fat, although the fat lobules may be somewhat larger and the fibrous trabeculæ more marked. Lipomas are poorly vascularized.

Comparative Pathology.—Rare in wild animals, rather common (especially the subperitoneal varieties) in domesticated animals. It is not an uncommon cause of strangulation of the intestine in the horse. The fat resembles that of the particular animal, there being an excess of olein in horses, of stearin in cattle.

Combinations: Fibroma, myxoma, and angioma.

Degenerations: Calcareous (affects the fibrous septa), myxomatous; saponification, ulceration, necrosis.

Clinical Features.—An hereditary predisposition to lipoma seems to occur in certain families. They do not waste in starvation. They are benign, do not recur after excision, usually have a thin, loosely attached capsule, and, as a result, are easily enucleated.

Fig. 70.—Lipoma of the right thigh (patient of Dr. B. M. Harding).

Diagnosis.—Lipoma may be mistaken for angioma, myxoma, soft fibroma, abscess or cyst. Lipoma shows no inflammatory reaction, is painless, has a lobulated edge, is soft, and gives pseudofluctuation; the skin, when raised, shows characteristic dimpling. The mass is not obliterated by pressure.

Clinical Varieties.—(1) *Lipoma molle:* Very soft, semifluctuating, with small amount of connective tissue. (2) *Fibrolipoma:* Firmer, with thicker trabeculæ. (3) *Diffuse lipoma:* Irregular, non-encapsulated lipoma, occurs in the neck, axilla, and groin. (4) *Nevolipoma:* Very vascular lipoma, found on the face and on subcutaneous portions of the periosteum.

Treatment.—Lipomas, while usually harmless, should be enucleated if producing annoyance or disfigurement. An *incision is made to the capsule*, and the tumor enucleated by the finger or knife-handle. Care should be taken that outlying lobules are not detached and left in the body.

Chordoma.—A rare, cherry-sized tumor, derived from the notochord, growing either at the base of the sphenoid, from which it is separated by a process of dura mater, or in the lumbosacral region. It is composed of small cells called "physaliphores"; it may become malignant and grow to a large size.

Angioma.—A tumor of blood-vessels, *hemangioma;* or of lymph-vessels, *lymphangioma;* is often indistinguishable from the more common enlargements produced by dilatation (*ectasia, angiectasis, telangiectasis*) of pre-existing vessels.

Angiomas are usually divided into the *telangiectatic* and the *cavernous*, dependent upon whether the vessels are increased in number or size.

A. **Hemangiomas** are tumors consisting chiefly of blood-vessels, and con-

tain capillaries, veins, arteries, connective tissue, and lymphatics. They may be diffuse, circumscribed, or even encapsulated.

Varieties.—1. *Angioma simplex* (*angioma glomeruliforme, angioma telangiectasia*) consists of dilated, new formed and pre-existing capillaries that intertwine and anastomose. These angiomas are usually congenital and occur in the skin (especially of the face), subcutaneous tissues, and, more rarely, in the brain or spinal cord and their membranes, often near the situation of fetal clefts (*fissural angioma*). The skin may be thickened, slightly elevated, smooth or irregular. The color is bright red (*nevus flammeus*) or bluish red (*nevus vinosus*), according to the character of the contained blood. The growths are compressible and, at times, pulsate. Sometimes the capillary walls are greatly thickened (*simple hypertrophic angioma*). The ectasia may involve a group of veins (*angioma simplex venosum*), and may contain phleboliths. *Nevolipoma* is an encapsulated telangiectatic lipoma.

2. *Angioma cavernosum* consists of a system of wide, irregular cavities separated by connective-tissue partitions, resembling in structure the cavernous tissue of the penis. It forms a diffuse, circumscribed or encapsulated, rounded or lobulated, soft, compressible, bluish tumor of the skin, subcutaneous tissue, liver or, more rarely, of the kidney, spleen, uterus, intestine, bladder, muscle, or bone. On the skin the growth is usually congenital. It may continue to enlarge, and by pressure destroy soft tissue, cartilage, and bone. After the second or third year it often undergoes atrophy and disappears. In the liver the angioma develops, in advanced life, by capillary dilatation with atrophy of the hepatic cells.

Telangiectasis or capillary dilatation occurs in many tumors, in chronic inflammatory disease of the skin, from radiation, and from obstruction to the central circulation. A capillary varix with radiating branches (*nevus araneus*) occurs upon the face—the so-called *spider cancer*.

3. *Nevus vasculosus* (*nevus angiectodes, port-wine mark, mother's mark, birth-mark*) is composed entirely of dilated veins and capillaries, is usually congenital, and has been ascribed to improper approximation of the embryonic planes (*Virchow's fissural theory*) or to pressure by maternal hard parts (*Unna*). The nevus forms a plum-colored or reddish, irregular blotch, usually upon the face or hands; the skin is smooth, of normal texture, and usually shows little elevation.

Varices (*varicosities, dilated veins*) are not true tumors, and are to be distinguished from angiomas. The dilatation chiefly involves the veins of the leg (*varicose veins of the leg*), hemorrhoidal plexus (*hemorrhoids, piles*), the veins of the dartos or the pampiniform plexus (*varicocele*), and, in hepatic cirrhosis, the veins around the umbilicus (*caput medusæ*) and of the lower end of esophagus.

4. *Angioma Arteriale Racemosum* (*Arterial Angioma, Angioma Arteriale Plexiforme, Cirsoid Aneurysm*).—A group of convoluted, dilated, thickened arteries, occurring chiefly about the head and scalp; of congenital or traumatic origin. The loud bruit may greatly annoy the patient and prevent sleep.

5. *Aneurysm by anastomosis* is a tumor of arteries, veins, and capillaries, with pulsation and bruit. It usually involves the head or trunk, and tends to increase in size.

6. *Plexiform angioma* consists of blood-vessels, which run more or less parallel to each other. It is rare, and occurs chiefly upon the scalp and upper lip.

Diagnosis.—Angiomas may be mistaken for lipomas, myxomas, soft fibromas, or cysts. They are compressible, the overlying skin may or may not show arterial dilatation and change of color, and the growth may or may not be sharply defined from the adjacent tissues.

Prognosis.—Cutaneous and subcutaneous nevi, cirsoid aneurysm, and angioma by anastomosis usually persist throughout life unless destroyed or removed. Very dangerous hemorrhage may follow wounds or ulceration of cavernous angioma. The congenital cavernous angiomas often enlarge and invade adjacent tissues in the early months of life, but frequently spontaneously disappear or, less frequently, enlarge during the first or second dentition or at puberty. Secondary malignant change is unusual.

Treatment.—Cutaneous nevi, when destroyed, usually leave a white scar which may have an irregular, depressed, or keloid surface. This should be understood by the patient before treatment is undertaken. If small, the secondary disfigurement is usually slight, while for an extensive "port-wine stain" it may make treatment unjustifiable. The following methods are used:

1. *Cautery Destruction.*—Nitric or trichloracetic acid is carefully rubbed into the growth by a pointed glass-rod or wooden stick until the affected layers of the skin have been destroyed, when a neutralizing (sodium bicarbonate) lotion or ointment is applied, and the eschar permitted to separate spontaneously.

If the *electric* or *Paquelin cautery* be used, local or general anesthesia is necessary. *Ignipuncture* consists in producing a number of small points of cauterization by heat.

2. *Fulguration or Electrocoagulation.*—The tissue may be destroyed by a high-frequency spark or contact.

3. *Electrolysis.*—Through fine, non-corrosive steel or platinum needles introduced into the growth 20 to 80 milliamperes of galvanic current are passed for from two to twenty minutes—at the negative needle *potassium hydroxid*, at the positive needle *nitric acid* is formed. The negative needle is moved from point to point, and the application immediately terminated when the skin becomes white. To prevent sloughing and excessive scar formation the poles should be insulated from the skin, and the nevus (if extensive) treated by repeated sittings at intervals of six weeks.

4. *Freezing.*—Carbon-dioxid snow is applied with pressure for from one-half to two minutes. This often fails to destroy the blood-vessels.

5. *Radiation.*—Radium or the Roentgen ray should be used cautiously. Excessive radiation results in telangiectasis and a disfiguring scar. It may be necessary to continue the treatments over several months or a year.

(a) For *superficial, flat angiomas*, or *port-wine stain*, the results from radium are unsatisfactory; heavy doses produce uneven fading, scarring, and telangiectasis. One-fourth of an erythema dose, with $\frac{1}{2}$ mm. of aluminum as a filter, may be used every other day for three or four applications, with no further treatment for at least eight weeks.

(b) *Elevated Angioma.*—Two applications, forty-eight hours apart, are made

with three-quarters of an erythema dose at contact, with $\frac{1}{2}$ mm. of silver as a filter. The dosage necessary to produce an erythema, with $\frac{1}{2}$ mm. of silver and contact, is twenty-two millicurie hours.

(c) For *small raised angioma*, and the submucous or subcutaneous growths, a dose just short of the erythema dose acts well. For larger, more extensive angioma, gamma-radiation gives the best result, using 1200 to 1400 millicurie hours. With a filter of brass the erythema dose is 2200 millicurie hours (Pfahler).

6. *Boiling Water Injections.*—From $\frac{1}{2}$ to 5 c.c. of boiling water are injected through a fine hypodermic needle directly into the growth, producing coagulation, necrosis, and obliteration of the vascular channels. It is better to depend upon several injections than to produce massive necrosis by a single large injection. Boiling water is more difficult to handle, and has little advantage over the injection of a 35 or 50 per cent. solution of *quinin* and *urea*.

Fig. 71.—Obliteration of angioma of the forehead by the injection of quinin and urea or absolute alcohol. Pressure of a ring is used to prevent diffusion of the drug into the circulation. For an infant not over 0.12 gm. of quinin should be used.

7. *Mass ligation*, as by Erichsen's ligature, is occasionally employed, the threads constricting the base of the tumor.

8. *Surgical excision* is sometimes desirable. It is wise to keep well to the periphery of the tumor in order to ligate the larger branches and avoid innumerable smaller vessels. Secondary skin-grafting may be required. Scarification, with superficial cross-hacking by a sharp knife to divide the innumerable blood-vessels, followed by the application of a firm pad moistened with quinin-and-urea solution (33 per cent.) may be tried for port-wine stains.

In extensive *cirsoid aneurysm*, a flap of scalp containing the enlarged arteries

is raised at the first operation, and separated from the scalp and skull by iodoform gauze. Two days later the vessels are ligated and excised from the under-surface of the flap, and the scalp replaced and sutured.

The tendency for *cavernous angiomata* to disappear spontaneously or after inflammation or dentition is to be remembered. By vaccinating over the growth, a scar may be obtained with obliteration of the blood-vessels.

B. **Lymphangioma** is composed of lymph-channels, with associated blood-vessels and connective tissue. It may be telangiectatic (*lymphangioma simplex, telangiectasis lymphatica*), cavernous (*lymphangioma cavernosum*), or cystic (*lymphangioma cystoides*). The vessels contain clear or milky lymph. Lymphangiomas occur congenitally in the tongue (*macroglossia*), palate, lip (*macrocheilia*), skin (*nevus lymphaticus*), neck (*hygroma*), vulva, and other parts. Acquired forms develop in the subcutaneous tissues, especially of the thigh and scrotum; the growth may fluctuate or be firm.

Chylangioma from the dilatation of lacteals is rare. In certain skin affections —as in the pigmented nevi, lentigines (freckles, ephelides), and especially warts (*verruca carnea*)—masses of cells, often pigmented, are found in the connective tissue of the papillæ or corium, and appear to have been formed by hyperplasia of endothelial cells of the lymphatics. There may be no lymphangiectasis. In elephantiasis and in many tumors, dilatation, multiplication, and hyperplasia of lymphatics are found. Like the hemangiomas, lymphangiomas are characterized by proliferation of new vessels, and are often indistinguishable from growths produced by an obstructive or inflammatory lymphangiectasis.

C. **Lymphomas** and **lymphadenomas** are tumors formed by hyperplasia of lymphoid tissue. They are usually rounded, circumscribed, and encapsulated, have a pale grayish surface on section, and are soft or firm according to the amount of fibrous stroma present. In structure they resemble the lymphatic glands, from which they usually grow.

Malignant lymphomas are characterized by marked hyperplasia of the lymphoid tissue, with great enlargement of the affected lymphatic glands and a tendency to local invasion and general metastasis. Radiation may delay the almost inevitable issue from two to five years. Excision is ineffective.

General lymphadenoma (Hodgkin's disease) is of unknown origin, apparently without diagnostic blood changes; is characterized by a marked hyperplasia of the lymphatic glands affecting, in order of frequency, the cervical, axillary, inguinal, retroperitoneal, bronchial, mediastinal, and mesenteric lymph-glands. The glands usually are discrete, but, at times, the lymphatic tissue penetrates the capsule and invades the adjacent tissue. Caseation is absent. Lymphoid growths may also develop in the spleen, liver, kidneys, alimentary tract, and bone. The condition tends to progress to death in two to four years.

Sarcoma.—A malignant tumor of the type of immature connective tissues. Mature connective tissues are differentiated by the characteristics of the intercellular substance. In sarcoma the cells predominate over the intercellular substance and determine the variety.

Varieties.—1. *Round-cell Sarcoma:* (a) Small-cell, (b) large-cell, (c) lymphosarcoma.

2. *Spindle-cell Sarcoma:* (a) Large-cell, (b) small-cell.

3. *Giant-cell sarcoma.*
4. *Melanosarcoma.*
5. *Mixed-cell sarcoma.*
6. *Alveolar sarcoma.*
7. *Angiosarcoma:* (a) Perithelial sarcoma, (b) plexiform sarcoma, (c) cylindroma.

Etiology is obscure. Sarcoma usually occurs between the ages of thirty and forty years, but may be congenital. Not infrequently it develops after a single violent injury, as a contusion or fracture. Inoculation and transplantation experiments have usually failed with sarcoma.

Seat.—Skin, subcutaneous tissue, fascia, subserous connective tissue, choroid, bone-marrow, periosteum, dura, brain and cord, lymph-nodes, blood-vessels, nerve-sheaths, submucous tissues, ovary, and uterus. Sarcomata are rare as primary tumors of muscle, heart, liver, pancreas, or lung. Secondary growths occur chiefly in the lung, skin, liver, and heart.

Pathology.—Rounded, lobulated or irregular, diffuse, circumscribed and frequently encapsulated, embedded, sessile or pendulous masses, with pale grayish or reddish-gray surface on section, often suggesting crab meat. The consistence is influenced by the type of cell, associated tissue, and degenerative changes.

Vascularization.—There is an abundant capillary blood-supply which, at times, produces visible pulsation and an audible bruit. The vessels consist of endothelium-lined channels through the sarcomatous cells, but there are also vessels with well-formed walls. Telangiectasis, cavernous change, and hemorrhage are common. Lymphatics are absent.

Microscopy.—The tissue consists of large or small, round, spindle-shaped, branched or multinuclear cells, with large, rounded or oval, vesicular nuclei, and a small amount of protoplasm. Mitotic figures and nuclear abnormalities (*hyperchromatosis*, *karyorrhexis*, *karyolysis*) are frequent. A homogeneous, granular, or fibrillar intercellular substance is always present, but often inconspicuous. The cells are intimately associated with the intercellular substance or stroma, to which they may send delicate cellular prolongations.

Combinations: Myxoma, chondroma, fibroma, osteoma, glioma, lipoma. Sarcomata may grow from glands of mesodermic origin (adenosarcoma), and by obstruction of the ducts produce cysts (cystadenosarcoma).

Degenerations: Fatty, calcareous, and myxomatous degeneration; cystic change and ossification, hemorrhage, inflammation, ulceration, and necrosis occur.

Clinical Features.—Sarcomata infiltrate locally, recur after removal, and give metastases. Usually they extend along natural spaces or channels, and have a limiting capsule. The degree of malignancy varies greatly. Metastasis, which chiefly occurs through the blood-vessels, is favored by the imperfect vessel walls, the loose attachment of the sarcoma cells, and the tendency for sarcomatous masses to grow in the blood-vessels. A wide-spread, general dissemination may occur (*miliary sarcosis* or *sarcomatosis*), the secondary growths resembling miliary tubercles. Metastasis to lymphatics is rare except in certain sarcomata found in the skin, mucous membrane, testicle, tonsil, lymph-glands,

and fascia. The round-celled lymphosarcoma and large spindle-cell sarcoma most frequently produce metastasis. The small spindle-cell sarcoma or fibrosarcoma recurs locally, and often does not produce metastasis. The softer varieties are usually more malignant and of more rapid growth. Periosteal sarcoma, however, is firm and very malignant; myxosarcoma is soft and often rather benign.

Comparative Pathology.—Sarcoma occurs more frequently than carcinoma in the lower vertebrates, including the birds and fishes. Melanotic sarcoma is especially common in gray or white horses, and usually occurs on the external genitalia or anus.

Round-cell Sarcoma.—1. *Small round-cell sarcoma* forms a pale, semi-translucent, pinkish-white, soft, friable tumor, resembling brain substance and exuding a milky juice upon section. It is very malignant, grows rapidly, in-

Fig. 72.—Ulcerating spindle-cell sarcoma of the right scapular region. Restrained for one year by enucleation and Roentgen-ray treatment.

filtrates, recurs, and gives metastasis. It consists of closely packed, small round cells containing large vesicular nuclei and but little protoplasm. There is but very small amount of intercellular substance, and the structure resembles that of lymphoid or granulation tissue. Unnecessary amputations have resulted from the mistake of considering granulation tissue to be sarcomatous. Therefore, to prevent an unnecessary mutilative operation, the clinical evidence should always be considered together with the area from which the microscopic section was removed.

2. *Large round-cell sarcoma* resembles small round-cell sarcoma, but is somewhat firmer and is less malignant. The cells are often arranged in irregular alveoli, formed by narrow bands of connective tissue or spindle-shaped sarcoma cells (*alveolar sarcoma*, formerly often called *medullary carcinoma*). Although the cells resemble those of carcinoma, the nucleus is relatively larger and more

vesicular, an intercellular substance may be demonstrated, and the cells are more intimately associated with the stroma than in carcinoma. Alveolar sarcoma produces metastasis less often than other varieties of round-cell sarcoma.

Lymphosarcoma consists of small round cells, embedded in a delicate fibrous matrix of branching cells and fibers. It grows chiefly from lymph-nodes or the thymus gland, resembles lymphoid tissue in structure, and is very malignant. The tendency to invade adjacent tissue, to recur and give metastasis, distinguishes it from the inflammatory hyperplasia of lymph-glands.

Spindle-cell sarcoma is the most common form of sarcoma. It is formed of (1) small spindle-cells or (2) large spindle-cells, producing a pale grayish, rather firm fibrous mass showing a convex surface on section. The cells have

Fig. 73.—Fungating melanosarcoma from the choroid of the left eye (Dr. Harding).

a large vesicular nucleus, may be spindle shaped or multinuclear, and have delicate projecting processes. At times there is much intercellular fibrous tissue (*fibrosarcoma, fibroplastic tumor, recurrent fibroid of Paget*). The spindle-cell sarcomas recur after removal, but metastasis is not as common as with the round-cell varieties. The large spindle-cell sarcoma is softer and more malignant than the small spindle-cell sarcoma.

Melanosarcoma (*melanotic sarcoma, melanoma*) usually is spindle celled, but may be a round-cell or an alveolar sarcoma in which the cells are pigmented with melanin, coloring the tumor a deep brown or black. It grows in the skin, often from pigmented moles, or the choroid and ciliary body. Many melanomas are of epithelial origin (*melanocarcinoma*). The melanin occurs as granules in and between the cells. On section an inky juice may exude. It is very malignant, and

almost invariably gives metastases to the skin and internal organs. Secondary tumors may have more or less pigment than the primary. The primary tumor is rarely very large, and cachexia usually is due to the secondary growths.

Treatment.—Free excision in the early stages. Recurrence is so common that the result of excision, with a growth at all advanced, is not promising. *Roentgen-ray treatment* may be used to retard the growth of the tumor. Enucleation of the eye for melanotic tumor of the choroid is almost invariably followed by a fatal recurrence in the liver. A brownish discoloration in tumors, resulting from extravasation of blood, should not be confused with melanotic pigmentation.

Osteoid Sarcoma (see page 245).—A sarcoma may ossify, or may be osteoid from the beginning with a skeleton of plates, scales, spines, or bony rays. The intervening soft tissues usually consist of spindle-cells. Osteoid sarcoma usually grows from bone, but gives rise to secondary osteoid growths of the internal organs. Calcification is much more common than ossification in sarcoma. The osteoid rays of bone, projecting at right angles to the surface of the bone in sarcoma, are to be distinguished from the concentric layers, parallel with the axis of the bone, deposited under the periosteum in inflammatory conditions.

Angiosarcoma. Sarcomas are usually very vascular tumors, and there is a tendency to telangiectatic or cavernous change of the blood-vessels. In angiosarcoma the tumor growth occurs along or from the blood-vessel walls, and the blood-vessels, therefore, determine the structure of the sarcoma. Angiosarcoma occurs in the brain, kidney, testicle, lymph-glands, skin, and bone.

Myxangiosarcoma tubulare or *perithelial sarcoma* is a very malignant small round-cell sarcoma, in which the sarcoma cells surround the blood-vessel, the intermediate tissue being myxomatous or degenerated. It may result from the growth of the sarcoma from the perivascular connective tissue, or degeneration of the tissue more distant from the blood-vessel. *Angiosarcoma* may pulsate and give a bruit.

Plexiform sarcoma is composed of thick, cellular tubes that intertwine and anastomose—a compound of blood-vessels with a thick encasement of sarcoma cells.

Cylindroma is a sarcoma ramified by cylindrical masses of hyaline or mucoid material; usually the blood-vessels have a thick, hyaline sheathing, the intermediate tissue consisting of sarcoma cells.

Psammoma (*Acervuloma, Sand Tumors*).—Certain sarcomas, fibromas, or myxomas, growing from the membranes of the central nervous system, or from the pineal gland, contain gritty particles resembling grains of sand. The lime concretions are concentric, irregular or nodular, and involve small areas composed of degenerated cells and hyaline connecting tissue.

Chloroma.—A very malignant greenish tumor (Lymphosarcoma?) growing from the periosteum of the skull, vertebra, ribs, and from other organs; is of lymphomatous nature, related to leukemia. The blood often shows lymphemia or myelemia, although leukocytosis may be absent. The tumors form firm, fibrous, broad flat masses (1 to 2 cm. thick) surrounding bones, and invading muscles, tendons, and vessels. The peculiar greenish color is produced by shiny bodies in the cells resembling fat.

The lymph-nodes may be greatly enlarged and fused, bone-marrow, extensively involved, the spleen much enlarged, and a diffuse involvement, as in multiple myeloma, may be present.

Chloroma occurs chiefly in adolescent males, and gives an average duration of life of six months.

Diagnosis of Sarcoma.—Sarcomas are to be differentiated from granulation tissue, the specific granulomas, and lymphoid hyperplasia. At times the diagnosis cannot be accurately made by the histologic study, but requires a careful evaluation of all clinical features.

Prognosis of Sarcoma.—Sarcomas include tumors of mild or intense malignancy. A *fibrosarcoma* (*recurrent fibroid of Paget*) may grow slowly and recur months or years after excision, but produces no metastasis. A *periosteal sarcoma* or *small round-cell sarcoma* often destroys life within six months or a year from the time it is first recognized. Against the more malignant sarcomas no effective treatment is known. Recurrence and rapid progress is often incited by local traumatism. A sarcoma will often disappear under radiation, to recur after two or three years, and resist all known forms of treatment. The more malignant forms of sarcoma are more amenable (temporarily) to radiation, toxins, proteins or other form of treatment than the more malignant carcinomas. They are less amenable to radical operation, extirpation or high amputation, due to early diffusion through the blood-stream rather than through the lymphatics.

Treatment of sarcoma is usually unsatisfactory. Recurrence and metastases are so common after *free excision* or even *high amputation*, and dissemination or rapid growth apparently is so often stimulated by operative trauma that the use of mutilative operations (except to overcome pain, hemorrhage, necrosis and toxemia, or troublesome deformity) should be limited. *Radiation* by the Roentgen ray or radium is a valuable palliative treatment in many cases, giving relief from symptoms for two or three years. Injection of the *mixed toxins* of Coley (*streptococcus* and *prodigiosus*) is followed by the disappearance of 2 per cent. of the sarcomas. Spontaneous disappearance (after the use of "teas" and medicaments, including injected proteins) is, while rare, more common than with other malignant growths.

Temporary improvement may be obtained in large, necrotic, fungating growths by shelling them from their capsules and applying antiseptics. Severe hemorrhage from an ulcerating sarcoma may be controlled by binding compresses moistened with turpentine over the part, taking care to protect the unaffected skin. The patient with ineradicable sarcoma should pursue a wholesome, hygienic life, and should be encouraged to continue at work and remain in the sunshine and fresh air as long as possible.

Endotheliomas are malignant tumors originating from endothelium, and resembling both sarcoma and carcinoma.

Seat: Dura, pia, pleura, peritoneum, lymphatics, testicle, ovary, liver, brain, parotid gland, and skin.

Macroscopy.—Usually firm grayish masses or nodulous thickenings, which may show areas of necrosis or, if near the surface, may ulcerate.

Microscopy.—Tubules or solid columns containing flattened and cuboidal endothelial cells usually embedded in dense connective-tissue stroma. The

alveoli are often arranged in parallel columns or in a plexiform manner, and the endothelial cells show an intimate relationship to the stroma. When tubules lined by endothelial cells exist, they may contain leukocytes in the lumen. The columnar and plexiform arrangement often corresponds with the course of blood-vessels. The occasional spindle-shaped forms, the attachment of the cells within the alveoli to the stroma, and the origin from endothelium are points of distinction from carcinoma. Endotheliomas grow rapidly, infiltrate widely, recur after excision, and give metastases through both the lymphatics and blood-vessels.

The treatment is similar to that for sarcoma or carcinoma.

EPITHELIAL TUMORS

Adenoma.—A benign tumor of the type of an epithelial gland.

Varieties.—(1) *Tubular adenoma.* (2) *Racemose, alveolar,* or *acinous adenoma.* Adenomas may be *circumscribed* or *diffuse.*

Seats.—Mammary gland, ovary, liver, thyroid, kidney; adrenal, salivary, lacrimal, sebaceous, and sweat glands; mucous membranes.

Morphology.—Firm, rounded or nodular, circumscribed, encapsulated or diffuse, sessile or pendulous (*adenomatous polyp*) growth; composed of tubules (*tubular adenoma*) or irregular acini (*racemose adenoma*), lined by a single or, more rarely, a double or triple layer of cuboidal or columnar epithelial cells. The arrangement of the tubules or acini is irregular, but a lumen is preserved and the lining cells are neatly arranged. The ducts do not empty into those of the gland from which the adenoma springs. The absence of duct outlets often leads to cyst formation (*cystadenoma, adenocele*), and papillary growths may occur from the cyst walls into the cavities (*cystadenoma-papilliferum*).

Fig. 74.—Adenomatous polyp of the upper lip. Easily removed by wedge-shaped incision.

Special names are given to *cystic adenomas* of certain glands, as *bronchocele,* of thyroid gland; *adenocele,* of mammary gland; *multilocular ovarian cyst,* of ovary. The latter may contain many gallons of fluid, and weigh up to 80 kilos.

Glandular hyperplasias from irritation should not be confused with true adenomas, nor should other tumors growing in association with glands, as adenofibroma, adenomyxoma, adenocarcinoma.

Hypernephroma (Struma Lipomatodes Aberrata Renis, Grawitz Tumor).—Yellowish, circumscribed, subcapsular renal tumor having a very vascular stroma, and with cells showing fatty, glycogenic, and pigmentary infiltration. Resembles in structure the adrenal cortex. Formerly thought to arise from misplaced particles of adrenal tissue in kidney. It is intensely malignant, and almost invariably fatal, giving metastases by blood-vessels to lungs, liver, bones.

Treatment of Adenomas: *Excision.*

Papilloma.—A benign tumor resulting from a new growth of papillary processes covered by epithelium.

Varieties.—1. *Hard Papilloma:* papillary processes covered by stratified squamous epithelium. 2. *Soft Papilloma:* papillary processes covered by columnar epithelium.

The varieties of *hard papilloma* (*verruca, wart*) are: (a) *Verruca vulgaris* - the common wart, seen upon the hands of children, probably a result of bacterial irritation. (b) *Verruca plana*—flat, pigmented wart, seen upon the backs of old people. (c) *Verruca filiformis*—long, thread-like wart, generally observed upon face or neck. (d) *Verruca digitata* –numerous long and projecting processes; occurs on scalp, back, and shoulders. (e) *Verruca acuminata* (*condyloma acuminata, venereal wart*)—reddish, usually multiple, cauliflower, sessile or pediculated growth, occurring about the genitalia; often due to the continued irritation from gonorrheal or other discharge. Warty growths occur about the mouth and anus in syphilis (*condyloma lata*). The venereal warts, arising from local irritation, are not true tumors.

Moles (*dermoid patches*) are pigmented, often hairy papillomas, that may be congenital or acquired. Occasionally the very fatal melanoma originates in a mole.

Seats.—Skin, gastro-intestinal tract, bladder, larynx, nasal cavities. Papillary growths occur in cysts of ovary and breast (*papilliferous cysts, cystadenoma papilliferum*). Wart-like growths may develop from a serous surface (as from choroid plexus) and be covered by a single layer of endothelial cells.

Morphology.—Papillomas are smooth, irregular, villous or dendritic, sessile or pendulous. The central papillary process consisting of connective tissue and blood-vessels is narrow or broad, and is covered (in the hard papillomas) with a thick layer of stratified squamous epithelium, in which may be found small rounded masses consisting of concentric layers of keratinized epithelial cells (*pearly bodies*). The soft papillomas are often villous, and are usually covered by a single layer of columnar epithelium.

Clinical Features. Warts are often due to parasitic irritation, and may recur or spontaneously disappear. They may be dangerous from their situation (as in larynx), hemorrhage (as in bladder), or tendency to carcinomatous degeneration.

Comparative Pathology.—In the lower animals, papillomas chiefly occur about the mouth and generative organs, usually result from irritation, and may spontaneously disappear when the irritating cause is removed.

Treatment.—1. *Destruction or eradication by caustics* (nitric or trichloracetic acid). For the smaller warts or callosities, the repeated application of sodium ethylate (prepared by dissolving metallic sodium in absolute alcohol) or a 5 to 20 per cent. solution of salicylic acid is effective, and may be applied by the patient.

2. *Destruction by fulguration or electrodesiccation.* Fulguration is valuable for papillomas on mucous surfaces, as of the bladder; the slender, insulated wire may be carried to the desired part by a cystoscope. The spark acts through watery solutions.

3. *Surgical excision.*

Callositas (*tylosis, callus*) is a hyperkeratotic area due to intermittent pressure and friction, occurring chiefly upon the flexor surfaces of the hands and feet with enormous hypertrophy of the horny layer, thinning of the middle layer, and flattening of the papillary layer of the skin.

Clavus (*Corn*): Localized hyperplasia of stratum corneum with projections into corium, producing pain and atrophy of papillæ. When situated over an inflamed bursa it is called a "bunion."

Treatment.—Twenty per cent. salicylic acid in ointment or collodion, excision.

Cornu Cutaneum (**Cutaneous Horn, Cornu Humanum**). -Horns grow from sebaceous cysts, scars or warts upon the skin, chiefly in elderly persons. The underlying papillæ are hypertrophied.

Varieties: (1) *Sebaceous horns*—arise from epithelial lining of sebaceous cyst, show longitudinal fibrillations, and are most common upon the scalp. (2) *Wart horns*—resemble sebaceous horns, but arise from warts, and are most frequent about the *corona glandis*. (3) *Cicatrix horns*—are usually laminated, are rare, and usually originate from the scar of a burn. (4) *Nail horns*—are elongated and greatly thickened nails.

Treatment.—Excision and removal, with cautery destruction or excision of the base from which the horn springs.

Odontoma.—Odontomas are tooth tumors that arise from the various constituents of developing teeth. Those originating in the enamel-organ are *epiblastic*, those from the dentin and cementum, *mesoblastic*. They attain a larger size in the superior maxilla and are usually first noticed between the ages of twenty and twenty-five. Outgrowths from developed teeth, especially those composed of cementum, are termed "dental osteomas." Clinically, odontomas are cystic, solid, or calcified.

Varieties (Bland-Sutton).—1. *Adamantinous multilocular cyst* (*epithelial odontoma*) arises from the enamel organ and is encapsulated. In the early stages it may be solid and contain branching columns of epithelium, the tissue resembling the *stratum intermedium*. Later, with cellular degeneration, a multitude of irregular cysts form, containing brownish, mucilaginous fluid.

2. *Follicular Odontoma* (*Dentigerous Cyst*).—A cyst containing the crown of a completely or partially formed, unerupted and usually misplaced tooth in a thickened, fluid-distended follicle.

3. *Fibrous Odontoma.*—An unerupted tooth, embedded in a thickened tooth-sac.

4. *Compound Follicular Odontoma.*—Consists of numerous denticles which progress to eruption, embedded in fibrous tumors.

5. *Cementoma* (*radicular odontoma*) arises from mesoblastic tissue of the tooth papillæ, after the crown is formed. The cementoma is rare except in ruminants.

6. *Composite* or *hard odontoma* arises from the entire tooth-germ, and consists of an irregular mixture of enamel, dentine, and cementum with multiple or multilocular simple cysts. Occurs in the molar region, angle or ascending ramus of the mandible, forming a large, disfiguring, hard tumor; often mistaken for sarcoma, but not malignant. It occurs in children and may suppurate.

Treatment.—Odontomas are benign, and should be treated by excision or resection with bone-cutting instruments or electrically driven burrs or drills.

Carcinoma (*Cancer*).—A malignant tumor, produced by a progressive infiltrative hyperplasia of epithelium. Consists of irregular collections of epithelial cells (in *nests, alveoli*, or *acini*) embedded in a vascular connective tissue (*stroma*).

Seat.—Carcinoma always arises from pre-existing epithelium, chiefly in the

cervix uteri, stomach, skin of the face, mammary gland (in women), sigmoid, colon, esophagus, ovary, testicle, penis, labia, pancreas, larynx, thyroid gland, liver. Cancers do not occur as primary tumors of the brain, cord, nerves, spleen, lymph-glands, bones, or cartilage. Metastatic carcinomata occur in the lymphatic glands, liver, lungs, spleen, brain, serous membrane, kidneys, and bones.

Varieties.—(1) *Squamous* or *flat-cell carcinoma* (*squamous epithelioma*) originates from squamous epithelium. (2) *Cylindrical* or *columnar-cell carcinoma* (*columnar epithelioma*), from columnar epithelium. (3) *Gland-cell carcinoma* (*carcinoma simplex*), from glandular epithelium.

The term "epithelioma" is applied to carcinomas originating from surface epithelium, and *does not include benign epithelial tumors*. The term "carcinoma" is sometimes restricted to those malignant tumors that develop from glandular epithelium. It is often difficult or impossible to distinguish between carcinomata derived from surface epithelium and those from superficial glands, and it is not improbable that many epitheliomata of the skin spring from sebaceous or sudoriferous glands, and of the intestine from the glands of Lieberkühn.

Etiology.—Obscure. 1. *Age:* Rare under thirty-five.

2. *Sex:* More common in women, except carcinomata of stomach, lip, and larynx, which are more common in men.

3. *Race:* Carcinoma is less frequent in negroes and savage tribes.

4. *Heredity* may at times predispose. Cancer is not inherited, but tissues with a tendency to undergo malignant change on irritation are transmitted.

5. *Geographical Distribution:* More prevalent in temperate than in tropical or arctic regions; in the North, Middle Atlantic, and Mississippi States; in Europe, China, North America, than in Egypt, Arabia, West Indies; in low lying, wooded, damp clayey, alluvial regions than dry sandy regions, and the areas of older geographical formation.

6. *Irritation:* There is a history of a single severe traumatism of the part in 2.23 per cent. (Villata). Continuous mild irritation is a much more definite factor, such as: (a) Irritation from working in tar (*tar cancer*), paraffin (*paraffin cancer*), arsenical dust, soot from smoking tobacco (cancer of the lip, tongue, larynx), from betel nut (*betel nut cancer* of the mouth). (b) *Mechanical irritation*—as the epithelioma of the lower lip in *clay-pipe smokers;* carcinoma of the tongue and buccal mucous membrane from the irritation of *teeth* or *dentures;* carcinoma following *chronic ulceration*, such as that of varicose ulcer of the leg (*Marjolin's ulcer*); carcinoma from *tense scars*, burns, lupus, syphilis; of the gall-bladder from *gall-stones;* of the cervix uteri from neglected *lacerations*. (c) Chronic local irritation from *burns*, especially from heat, radiation by Roentgen ray or radium, and *exposure* to the sun and wind, as in the *radiation epithelioma* and *epithelioma of the face* in farmers and sailors; *carcinoma of the body* following burns from the kangri basket, which the natives of Kashmir carry against the body for warmth; *cancer of the mouth and esophagus* in Japanese men from eating hot rice (rare in Japanese women who wait upon the men and eat the rice cold). (d) *Chemical* or *bacterial irritation*, carcinoma of the stomach, is more common in patients with chronic gastric ulcer, and preceding hyperacidity; the so-called *anilin cancer of the bladder* occurs in anilin workers. (e) Irritation from *parasites*, as in cancer of the bladder from bilharzia infection, and in the stomachs of rats from infected cockroaches.

7. *Infection:* A parasitic origin has not been proved. Rarely carcinoma has occurred in a succession of persons occupying certain houses. Carcinoma, while autotransplantable, is rarely inoculable in other persons. A very few cases of the apparent inoculation of surgeons, nurses, or attendants have been reported. Transplantation of tumors in lower animals has only been successful with a limited number of growths, and chiefly in mice, rats, and birds.

Pathology.—Usually there is a firm, uncircumscribed, adherent, grayish, irregular, nodular growth which contains fibrous tissue and often fat, tending to involve adjacent surfaces, and to produce deep, foul ulcers with ragged, indurated, everted borders. The tumor is often umbilicated and, when the mammary gland is affected, the nipple is usually retracted. The adjacent skin becomes brawny and coarse (*lardaceous, pig-skin appearance, orange-rind appearance*). The cut surface is usually concave, and on scraping or pressure exudes a milky fluid, or "cancer juice." Secondary carcinomata are usually multiple, rounded, circumscribed; are softer than and have different seats from primary carcinomata. Primary carcinomata are rarely multiple.

Microscopy.—Carcinoma consists of: *Acini*, which vary much in size and shape from long narrow alveoli, having but a single or double column of cells, to wide, irregular, or rounded cavities. The shape of the acini is determined by the lines of least resistance to the epithelial invasion. They intercommunicate, and connect with or may consist of lymph-channels. They have no membrana propria, and the contained cells have no intimate connection with the stroma. The acini are usually filled with a compact mass of cells, or more rarely, as in adenocarcinoma, a lumen is present. Cartilage and bone may be invaded.

Carcinoma cells are polymorphous, irregularly grouped, and usually have vesicular nuclei and a comparatively large amount of protoplasm. Mitotic figures and nuclear degenerative changes are common. The cells are without intercellular substance, except the usual cement substance, and are, therefore, readily washed or penciled from the alveoli. The cells, especially about the periphery of the nests, tend to resemble those of the parent epithelium. Large, polyhedral cells, with small nuclei and at times prickles, tending toward the center of the acini to undergo the horny change, are found in squamous epithelioma. The peripheral cells of the acini are columnar and may show mucoid degeneration in columnar epithelioma. The peripheral cells are irregularly cuboidal, and may show fatty degeneration in mammary carcinoma. In the center of the nest the cells are distorted from mutual pressure.

Very large cells (physalides), that contain large vacuoles and often are multinuclear, are found in giant-cell carcinoma. The cells may show degenerative changes, especially those degenerations common to the epithelium.

A viscid fluid (resulting from pseudomucoid, mucoid or, more rarely, true colloid degeneration of the cells) distends the alveoli in colloid carcinoma.

Pigmentation of the cells by melanin (*melanotic carcinoma*) is rare, but occurs in certain very malignant carcinomas of the skin.

Stroma consists of invaded pre-existing connective tissue and of new connective tissue formed as a result of the invasion. When in large amount, a firm tumor is produced (*scirrhous carcinoma*); when the alveoli are large and the stroma is small in amount, a softer carcinoma results (*medullary* or *encepha-*

loid carcinoma, carcinoma molle). The stroma may undergo myxomatous degeneration (*carcinoma myxomatodes*), or rarely may contract upon the alveoli, checking the invasion and practically obliterating the acini (*atrophic* or *withering scirrhus*). This latter condition may not, however, prevent metastasis. Leukocytic infiltrations are common.

Vessels.—The stroma contains many well formed blood-vessels that do not invade the acini. Lymphatics are present.

Combinations: Papillomas, adenomas, and dermoids may become carcinomatous, and carcinoma may invade connective-tissue tumors.

Degenerations are: Fatty, cloudy swelling, serous infiltration; mucoid, colloid, hyaline, amyloid degeneration; calcification (of epithelial pearls); inflammation, necrosis.

Diffusion.—Carcinomas spread by *local infiltration* and *permeation* (Handley). Local infiltration is the invasion of the adjacent tissues by the carcinoma; permeation refers to the passage of carcinoma cells, along the lymph-spaces and lymph-vessels, toward tributary lymphatic glands. The lymph-spaces first become filled with cells, and then, by a perilymphatic fibrosis, the space is contracted and the contained carcinoma cells obliterated. This obliteration, however, occurs after the permeation, and does not prevent the wide diffusion of the carcinoma through the lymphatics. The peripheral lymphatics about the tumor may therefore contain carcinoma cells, while the intermediate lymphatics from obliterative change show no evidence of carcinoma. The tributary lymph-nodes become enlarged, firm, hard, nodular or craggy, and the process then spreads on to the second lymphatic barriers. Secondary edema and a brawny condition of the tissues result from lymphatic obstruction. Metastasis through the blood-vessels is less common, but may produce a rapid general infection (*acute miliary carcinosis*).

Lymphocytosis, common in carcinoma, is probably a protective reaction. The resistance of animals to experimental cancer is reduced by exposure of the Roentgen ray which destroys the lymphocytes, and cancer patients with high lymphocyte count give the best prognosis.

Index of Malignancy (Broders).—The immaturity of the cells, low degree of differentiation, and high degree of anaplastic changes are invariably associated with a high malignancy index. The greater the maturity of the cells, the higher the differentiation, and the less the anaplastic changes, the lower the malignancy index. On this basis carcinomas are classed in groups 1, 2, 3, and 4.

Comparative Pathology.—Carcinoma affects nearly all vertebrates, but is rare in wild animals and in herbivora. It occurs in domesticated animals, including horses and animals in captivity, but is less common than sarcoma.

Symptoms of Precancerous Lesions.—An eczematous, scaly, ulcerative, papular, or warty lesion may precede the active development of an epithelioma by many years. The age of the lesion rather than the age of the patient determines the time of onset of the cancer. The *precancerous dermatoses* include lupus vulgaris, lupus erythematosis, arsenical keratoses, psoriasis, pigmentary nevi, and xeroderma pigmentosum. Keratoses from radiation or other burns, and from the scars of syphilis or tuberculosis not infrequently are followed by the development of carcinoma. *Lupus carcinoma* usually arises in scar tissue after

the fifth year, usually about the thirtieth year of the tuberculosis. *Radiation dermatitis* proceeds to epitheliomatous change in three to eleven years.

Dermatitis papilloma malignans (*Paget's disease of the breast*) usually affects the right breast of women between thirty-five and sixty years of age. Men are not exempt, and the scrotum, face, and other parts may be involved. It is characterized by sharply outlined areas of superficial ulceration with vivid red surface, viscid yellowish discharge, slightly elevated circinate borders, and superficial parchment-like induration. It resists medication, and carcinoma usually supervenes in from six months to several years.

A chronic mastitis often precedes the development of *mammary carcinoma.*

Leukokeratosis or *Leukoplakia Buccalis* (*Leukoma, "Smoker's Patches"*).—Whitish or bluish-white, flat, stiff, rather dry patches, occurring in the mouth, on the tongue, or cheek, that tend to develop fissures, ulceration, or papillary growth, and often are followed by the development of epithelioma.

Marjolin's Ulcer.—A chronic epitheliomatous ulcer (often originating from a cicatrix or varicose ulcer) that forms parallel, wart-like growths, with epithelial

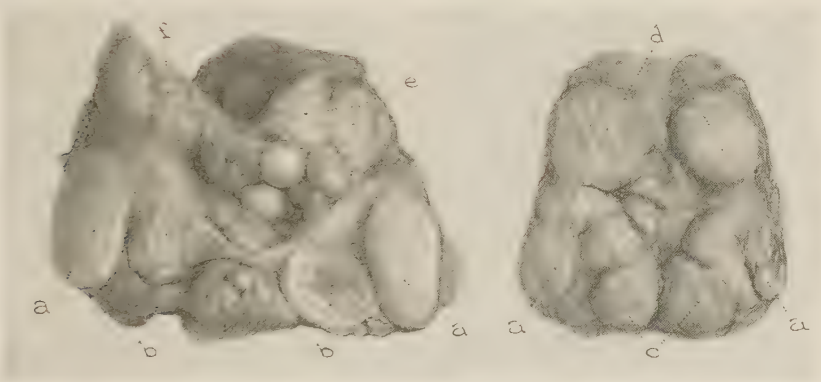


Fig. 75.—Enlarged lymph-nodes from axilla containing metastatic carcinoma: *a, f,* Lymphoid tissue; *b, c, d, e,* carcinomatous tissue.

infiltration of the adjacent tissue and metastasis to the adjacent lymph-glands from the epithelioma.

Bowen's precancerous dermatosis (Bowen, 1912) is characterized by painful single or conglomerate, scaly, dull red papules upon the skin that slowly progress to malignancy after ten to thirty years. The epidermal layers are markedly hyperplastic, the corium edematous and infiltrated by plasma cells.

Clinical Symptoms.—The *tumor* of cancer usually is irregular, craggy, fixed, infiltrative, and at times umbilicated.

Ulceration and *hemorrhage* occur early from cancer involving the surfaces of the body. The ulcer has a craggy necrotic base and thick, rolled, indurated, and infiltrating border.

Pain is slight or absent in the early stages of cancer. A mild tingling, pricking, darting, or throbbing sensation may be noticed. In the later stages from pressure, obstruction, ulceration, and infection and the involvement of sensitive parts violent pain may be caused.

Lymphatics.—The adjacent lymphatics are involved early (except from basal-cell epithelioma) and the lymph-nodes become large, firm, nodular, or craggy.

Metatastic nodules on the surfaces of internal organs often are firm and umbilicated.

Cachexia is more marked in the later stages of carcinoma than with any other form of tumor. It results from hemorrhages, products of bacterial invasion, or metabolic poisons produced by the degenerating cells, and mechanical interference with important functions. It is characterized by wasting, asthenia, yellowish pallor, and sometimes by chloasma and other skin eruptions.

Gland-cell Carcinoma: (a) Carcinoma simplex. (b) Scirrhous or fibrocarcinoma—firm from the excess of fibrous stroma. (c) Encephaloid, medullary carcinoma, carcinoma Molle—soft, with preponderance of epithelial cells over the stroma.

Gland-cell carcinoma occurs in the mammary gland, liver, thyroid, salivary glands, prostate, pancreas, kidney, testicle, ovary, and uterus. A milky fluid may exude on section; the alveoli are irregular and the cells polymorphous. It is a very malignant and common form of carcinoma.

Colloid carcinoma (*carcinoma gelatinosum*, "*gum cancer*"), a soft growth, containing gelatinous, translucent, colorless or yellowish material; involves chiefly the pylorus, intestinal tract, thyroid gland, ovary, and bladder. At times the degeneration of all the epithelial cells in the alveoli produces a honeycomb appearance, the thin walls of alveoli and the gelatinous contents being visible in cross-section. The degenerative process may affect the intercellular substance rather than the cells; the material is usually mucin or pseudomucin, and rarely true colloid.

Carcinoma cylindromatosa is a rare form of carcinoma, in which cylindrical areas of cells have undergone hyaline degeneration.

Melanocarcinoma is rare, usually originates on the skin, is soft and very malignant. *Carcinoma telangiectodes* is one containing many blood-vessels. The term "*fungus hæmatodes*" was applied to bleeding fungous, very malignant carcinoma as well as to sarcoma, by the older writers, or the term "*noli me-tangere*" (do not touch me).

Squamous-cell cancer: *Spinocell cancer, prickle-cell cancer, hornifying squamous epithelioma, acanthoma, epithelioma, epidermoid cancer,* cancroid, flat-cell cancer, skin cancer is derived from the squamous layer of the epidermis and is characterized by the formation of pearly bodies.

Etiology.—Age: Chiefly between forty-five and seventy years. When developing in chronic scars from burns, lupus, or radiation, it is frequent below the age of thirty. *Sex:* Men more often affected than women. Apparently there is no racial immunity.

1. Chronic irritation, rough tooth, dental plate, pipe or cigarrette smoking, burns, cuts from shaving.

2. Dermatoses, senile keratoses, warts, seborrheic keratoses, leukoplakia, psoriasis, papillomas, cutaneous horns, and the irritation of benign warts. It is rare after lupus erythematosus, but occurs in scars from burns, injury, syphilis, tuberculosis, especially lupus vulgaris and radiation dermatitis; in chronic un-

healed sores, cracks of the lips, varicose ulcers, chronic sinuses and fistulæ. It is almost unknown in the scar from blastomycosis.

3. Chemical irritation of the skin from tar, pitch, soot, shale oil, paraffin, anilin dyes, arsenic, quicklime, anthracene, tobacco; but not from iodin, coal-dust, or blast-furnace dust; anthracene more than naphthalene or creolin. Of the anilin dyes the irritation from Bismark brown, paranitranilin (red), and especially nitro-dinitrochlorbenzene favors the malignancy. These irritations occur: (a) Associated with occupations involving the distillation of coal, the handling of pitch, shale oil, or paraffin; (b) in chimney sweeps; (c) in the use of tobacco and betel nut. The latent period of irritation before a cancer develops averages about ten years.

Site.—Mucocutaneous border of the lower lip, the face, ears, scalp, extremities, tongue, scrotum, and penis. The scrotum is affected in tar, pitch and paraffin-oil workers, and in chimney sweeps.

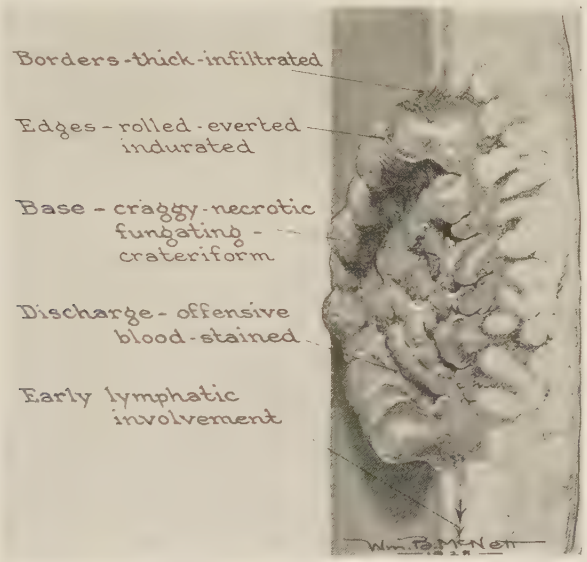


Fig. 76.—Clinical characteristics of an ulcerating squamous epithelioma.

Pathology.—(1) A papillary, or (2) ulcerative, deep infiltrating growth, crusting and forming irregular, indurated, translucent, grayish-pink nodules. The ulcerative type has an abraded surface with elevated, rolled, thickened edges, and extensive deep induration. It is usually firm and grayish on section, and on pressure may exude cylindrical masses of epithelial cells.

Microscopically: Wide or narrow, irregular, branching columns, consisting of solid masses of epithelial cells, are found projecting through the corium into the subcutaneous tissue. The cells are large with small nuclei and resemble the parent-epithelium cells. In the columns, concentric masses of flattened keratinized cells may be seen (epithelial pearls). The intervening stroma may be in large or small amount; it contains the blood-vessels and usually shows leukocytic infiltration.

Symptoms.—Epitheliomas of the skin are often preceded for many years by a scaly, crusted, or warty lesion. The epithelioma appears as a firm infiltrating tumor, a papillomatous growth, or an ulcer with a crusted surface and hard infiltrating base. It grows more rapidly than rodent ulcer and, on the lower lip, metastasis may occur within one month. The papillary type is less malignant than the ulcerative and infiltrative. The superficial epitheliomas, especially of the nose, ear, and eyelid, are less malignant and may persist for years without serious results. The deeper epitheliomas, and those affecting the penis, lips, and face, just anterior to the ear, are much more malignant, often with an early involvement of the adjacent lymph-glands. They gradually progress with the destruction of cartilage, periosteum, and bone.

In old ulcers or dermatoses, epitheliomatous change is shown by increasing ulceration with thickened base and everted edge, infiltration, pain, and the enlargement of the regional lymphatics. From the lower lip metastases first occur to the submental and submaxillary glands, and then to the upper

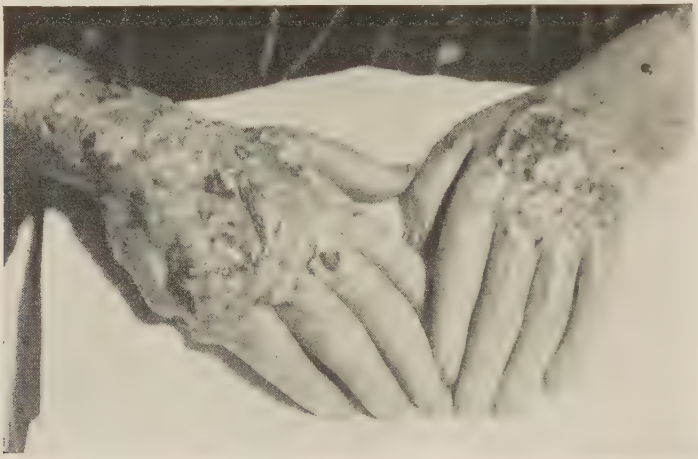


Fig. 77.—Squamous-cell carcinoma following Roentgen-ray dermatitis (Ewing).

cervical and lower cervical glands, both superficial and deep, with exceptions. Visceral metastasis is rare, and cachexia and anemia occur late in the process.

Diagnosis.—An indurated, growing papilloma of pin-head size requires free excision and microscopic study. From rodent ulcer epidermoid cancer is distinguished by rapidity of growth, deeper infiltration, and lymphatic metastasis.

Prognosis.—(1) *No Lymphoglandular Enlargement:* (a) With free excision of primary growth, 66 per cent. of the patients remain free from the disease more than five years. (b) If the adjacent submaxillary glands are also removed, 92 per cent. of the patients remain well for more than five years after the operation. (2) *Associated Lymphatic Metastasis:* After removal of lesion and glands 34 per cent. have no evidence of the disease after five years (Meyer).

If treatment is delayed until the adjacent lymphatics are adherent and the tissues edematous, recovery is rare.

Recurrence is favored by delayed or late operation, incomplete excision, and

careless handling of tissues with implantation of cancer-cells at the time of operation. Free excision before the growth is more than 3 mm. in diameter is almost invariably curative (Bloodgood).

Scar Carcinoma (Marjolin, Dictionnaire de Médecine, 1828).—Squamous-cell rather than basal-cell epitheliomas usually develop in scar tissue.

Etiology.—The *age of the scar* rather than the *age of the patient* determines the development of the carcinoma. Irritating scars, that have been present from childhood, not infrequently show epitheliomatous change between the ages of twenty and thirty-five. Scars from burns, Roentgen rays, radium, lupus vulgaris or, less frequently, lupus erythematosus, and from chronic varicose or syphilitic ulcers (especially if the seat of chronic traction, irritation, abrasion, or chronic ulceration) are prone to malignancy. Special names have been given to some of these growths, such as: (1) *Marjolin's ulcer*, the epithelioma developing in a varicose ulcer of the leg. (2) *Kangri cancer*, developing upon the trunk, following burns from the kangri basket.

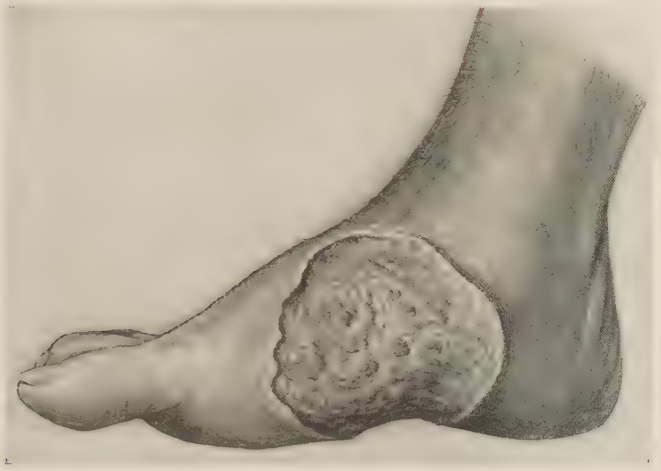


Fig. 78.—Marjolin's ulcer (epithelioma) of the foot.

Webs of scar tissue that bind the arm to the trunk, the forearm to the arm, the head and neck to the chest, such as result from extensive burns, are prone to malignant change.

Symptoms are insidious. The chronic ulcer situated in dense scar-tissue may show little change at the onset of malignancy, but enlarges slowly with little formation of new tissue until the underlying lymphatic spaces are invaded, when rapid growth with metastasis to adjacent lymphatics and often to the lungs and liver follows.

On radiation burns, areas of keratosis and wart-like masses are suggestive of malignant change. Pain, thickening of the edges of the ulcer, increased vascularity in an old ulcerated area, and the development of thick scabby masses, keratoses or papillary outgrowths upon an old scar are suspicious, and a portion of the tissue should be excised and examined microscopically. If the tributary lymph-nodes are invaded the condition is usually hopeless.

Carcinoma lenticulare or *carcinoma tuberosum* are multiple secondary nodules on the skin. Tuberous carcinoma is usually secondary, but may be primary. It forms painful discharging ulcers resembling syphilitic rupia.

Basal-cell epithelioma (*rodent ulcer, cancroid ulcer, Jacob's ulcer* [Jacob, 1827], *sebaceous carcinoma, ulcers exedens, reticulated epithelioma*) occurs chiefly upon the face, neck and scalp, more rarely upon the trunk as a smooth rounded papule which after several years progressively ulcerates, destroying adjacent soft parts, cartilage, and bones, with hideous deformity. It never heals, does not give metastases to lymph-glands or organs, and if widely excised occasionally does not recur. It is found chiefly in middle-aged men as a smooth, rounded, flat papule or smooth wart, which ulcerates, enlarges, and resists treatment.

Fig. 79.—Basal-celled epithelioma of the face in a man of thirty (Stokes).

A local erythema, eczema, or seborrhea may precede the development of the growth. The secretion is thin, serous, appears somewhat purulent, and hemorrhages may occur.

The edges are raised (wire edge), nodular, indurated, pearly, and hyperemic. The eye, ear, and nose may completely be destroyed. The middle ear, cranial sinuses, meninges may be invaded, or large vessels entered, with fatal hemorrhage.

Microscopically, solid irregular cylinders of epithelial cells ramify through the involved tissues. The cells are of the basal type, small, polyhedral, or spindle-shaped, with relatively large vesicular nuclei and scanty cytoplasm. Hornification and pearl formation are absent. The tumor arises in the basal cells of the malpighian layer and the ducts of the sweat, hair, and sebaceous follicles.

Adenoid epithelioma of the skin is a variety of basal-cell epithelioma of low malignancy, which may be cystic and form multiple, firm, painless nodules, usually upon the skin of the face, scalp, or upper part of the body, developing about the age of puberty. The simple adenoid epithelioma is more malignant than the cystic form.

Basal-squamous-cell Epithelioma.—A transitional form between the basal-cell and the squamous-cell epitheliomas, clinically resembling basal-cell epithelioma; characterized microscopically by both basal cells and cells (intermediary between basal and prickle cells), larger than the basal cells, with large lighter staining nuclei and imperfect cellular bridges, and, occasionally, partial pearl formation; at times producing metastasis to lymph-glands or other parts, thus differing from the pure basal-cell type. Basal-squamous-cell epithelioma is radio resistant, and arises both from mucous membrane and skin.

The *prognosis* should be guarded; and the *treatment*, very free surgical excision, with removal of tributary lymph-nodes.

Terebrant ulcers are characterized by slowness of evolution (ten to thirty years), tenacity, and localized malignancy, with a tendency to death by hemorrhage and from meningitis.

Cylindrical Epithelioma (Columnar- or Cylindrical-cell Carcinoma).—Seat: Pylorus, rectum, cecum, and uterus. The tissue is infiltrated by tubular acini, irregularly lined by columnar epithelial cells. There is usually a lumen, and the acini may be filled by epithelial cells of an irregular shape. The growth usually is rather soft and papillary, and may originate from a soft papilloma. It produces local infiltration and metastasis and, as a rule, is more malignant than squamous epithelioma. It probably often originates from glandular epithelium, and similar growths occur in the kidney, mammary gland, and liver. It resembles adenocarcinoma.

In the uterus, the squamous epithelioma of the cervix shows greater tendency to infiltrate and to recur than does the columnar or adenocarcinoma of the corpus uteri.

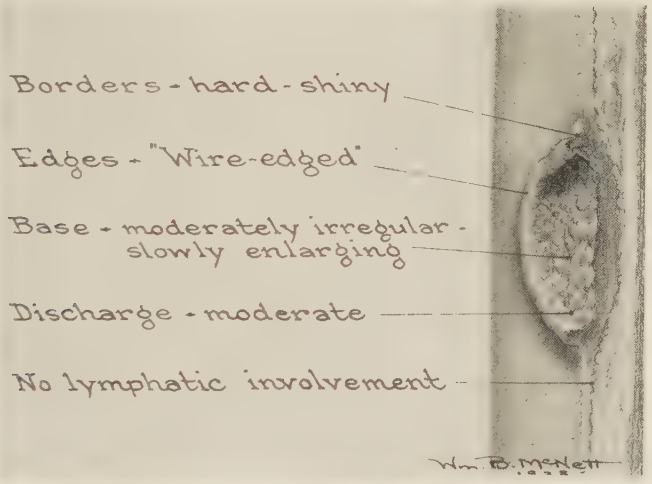

Borders - hard - shiny
Edges - "Wire-edged"
Base - moderately irregular - slowly enlarging
Discharge - moderate
No lymphatic involvement

Fig. 80.—Clinical characteristics of rodent ulcer or basal-cell epithelioma.

Chorio-epithelioma *(syncytioma malignum, deciduoma malignum, sarcoma deciduocellulare)* is a soft, vascular, hemorrhagic, infiltrative tumor arising from cells lining the chorion, characterized by invasion of the uterine walls, and metastases through the blood-vessels to the external genitals, lungs, liver, and spleen. It consists of an irregular network, composed of columns and masses of cells of the epithelial type from the syncytium, growing in the vascular sinuses. There are also adjacent masses composed of smaller irregular cells (Langhan's cells). Thrombi and leukocytic infiltrations are common.

Prognosis.—The superficial squamous epithelioma, the basal-celled epithelioma, the withering scirrhous and colloid carcinoma are relatively less malignant than the deep-seated epithelioma, epithelioma of mucocutaneous junctions, and medullary carcinoma. Carcinomas are more dangerous in young patients, in obese patients, and in those with diabetes. The growth of the tumor is usually slower in aged and emaciated patients. The more embryonic

the type of epitheloid cell present, the greater is the malignant tendency. A wide-spread invasion of adjacent lymphatics by carcinoma cells renders complete extirpation difficult and recidivity common.

Treatment of Carcinoma.—*Prophylactic.*—The irritation of a scar from friction, traction, and abrasion should be prevented. Scars showing chronic ulceration, or restricting normal movement, should be excised and replaced by grafts of elastic skin. Areas of keratosis should be excised and treated by skin grafting, or destroyed by fulguration. If malignancy is found, radical excision should be performed, with removal of the tributary lymph-nodes. If an extremity is involved—unless the growth is very local or superficial, and has not invaded the vascular subcutaneous tissues—high amputation, including the removal of the tributary lymphatic glands, is often necessary to save life.

Treatment in the Early Stage.—Before metastasis has occurred, *free excision* is the preferred treatment for cancers of the face, mouth, tongue, stomach, intestine, rectum, kidney, and bladder. The original growth should be removed with a wide margin of sound tissue, and the first *barrier lymphatic glands removed en masse*, radiated, or implanted with *radium*. For cancer of the lip or tongue the submaxillary and submental triangles are cleared *en bloc*, but the intervening tissue of the floor of the mouth need not be included.

Later Stage.—When the superficial lymph-nodes are invaded, the tributary deep chain should also be removed. Preoperative radiation is not desirable, as the resulting inflammatory reaction favors dissemination. In squamous-cell carcinoma of the scalp and forehead, removal of the cervical nodes is not required; but in cancer of the face, cheek, eyelid, chin, and nose the glands should be removed. In the extremities and scrotum, metastasis occurs to the regional glands, which should be excised. In cancer of the ear, the parotid, preauricular, postauricular, or other cervical glands may be involved, and should be removed. The growth also may be destroyed by the actual *cautery*, electrocoagulation, implanted radium, or chemical caustics.

Pyrogallol has somewhat of a selective action and may be applied for a superficial growth in 25 per cent. strength, in ointment, for from three to fourteen days. *Marsden's paste* consists of: Arsenious oxid, 1 part; powdered acacia, 1 part; cocain, $\frac{1}{3}$ part; sufficient water being added to make a stiff paste. It is applied upon rubber for twelve to thirty-six hours, according to the depth of action desired, after which poultices or wet compresses are used until the slough separates. *Zinc chlorid* is used in the form of *Bougard's paste*, which is applied for twelve to forty-eight hours. If an ulcer is not present the epidermis should first be removed by blistering.

Cautery Destruction in Malignant Disease.—(1) *The heat is generated in the applicator* (electrocautery, galvanocautery, Paquelin or Percy cautery), which is always hot when applied, and cauterizes or burns the tissues. The tissues may be rapidly charred, or slowly heated to a degree above the thermal death-point of the tumor-cells (113° to 115° C.), as with the Percy cautery. Certain of the normal tissues withstand a temperature of 130° C. or more.

(2) *Endothermy* is characterized by the use of a cold electrode, in direct contact with the skin and without the employment of a spark. The heat is generated in the tissues without charring or burning.

Diathermy refers to the *medical* application; *endothermy*, the *surgical* application of high-frequency currents. Endothermy includes the monopolar high-frequency current, the bipolar high-frequency current, and the endotherm knife. As the electrode is held in contact with the tissue, sparking occurs only on entering or withdrawing the electrode. Muscular contractions cease with oscillations above 10,000 per second. *High-frequency* currents have more than 500,000 oscillations per second; *low-frequency* currents are those with a lower number of oscillations.

(a) *Electric desiccation* (*monopolar endothermy*) is the lightest or *desiccating current*, having a high voltage and low amperage. It is used for superficial precancerous and cancerous lesions, warts, moles, nevi, tattoo marks, carbuncles. An ordinary steel sewing-needle in a suitable handle serves as the electrode. The adjustment is so delicate that pin-point areas on the cornea or vocal cords may be destroyed. The tissues are dried, but not carbonized. The desiccated tissue is then curetted away.

(b) *Electric coagulation* (W. L. Clark) is bipolar endothermy with a deeply penetrating, coagulating d'Arsonval current of comparatively low voltage and high amperage. An ordinary steel sewing-needle forms a satisfactory electrode. A wet indefinite electrode is placed under the patient's buttocks. Local or general anesthesia is used. Sensory nerves are destroyed, relieving pain. There is no smoke or high temperature. Electrocoagulation is used to destroy the deeper and more extensive growths, against which it is very efficient. Electrocoagulation of the primary lesion is often followed by or associated with radiation by Roentgen ray. Metastatic nodules should be dissected out, or radiated by embedded radium-needles. Recurrences and well-defined metastases are not eliminated by radiation alone, which does not completely destroy a fully developed epidermoid carcinoma in the lymph-nodes.

(c) *Endotherm* or *Radio Knife*.—In the endotherm knife, the DeForest modification of the Fleming tube is used, which acts as an amplifier, producing a short spark with oscillations increased to 6,000,000 per second. A needle-point (or small wire-loop) carrying these short sparks causes the tissues to fall apart by molecular dissolution. The tissues are rapidly divided without pressure, and the local destructive action is so superficial that the united wound heals by primary union, with a thin fine scar. The current from the 3-element vacuum-tube also seals the lymphatics and checks hemorrhage from the smaller vessels.

Endothermy is also used for leukoplakia, epulis, ranula, hyperplastic tonsils, malignant growths, hemorrhoids, fissures, and fistulæ.

(3) *Fulguration*, *high-frequency caustic spark* (Pozzi), is the local application of the high-frequency destructive spark through a gap of air or water. It has a superficial destructive action upon the tissues, is used for destroying growths upon the skin and mucous membrane, especially vesical papillomata. It has been employed by de Keating-Hart to aid in the destruction of large malignant growths. The method is painful and in treating the larger growths an anesthetic should be used.

Radium gives off alpha and, indirectly, beta and gamma rays. The alpha rays are positively charged atoms of the gas helium. With the loss of helium atoms, radium atoms are transformed into a gas (*radium emanation*). This gas also gives off helium atoms and is again transformed into a metal and finally into six other metals forming a mixture termed *active deposit*, from which alpha, beta, and gamma rays emanate. Despite the continuous emanation the loss or decay of radium is almost infinitesimal.

The alpha rays, which are softest, least penetrating, but most destructive to the tissues, are arrested by an aluminum screen 0.01 mm. thick, while the gamma rays, hardest and most penetrating, pass through 10 mm. of lead. The softer rays produce tissue necrosis in a radius of about 1 cm. On the skin this causes an indolent and often painful ulcer; in the vagina or rectum, a troublesome fistula; in tumors, a destructive effect to be compared with that of a cautery or caustic. To prevent destruction of normal tissues by the alpha and beta rays and the softer gamma rays, screens of aluminum, platinum, silver, brass, and lead are used, or the radio-active substance is separated from the tissues by such a distance that the softer rays are ineffective.

Therapeutic radiation is obtained directly from: (a) *Radium* used in the form of a soluble bromid, or insoluble sulphate; (b) the *active deposit* usually collected on thin sheets of lead which are applied to surfaces; or (c) *radium emanation* usually collected in capillary glass tubes from 0.3 to 0.6 mm. in diameter and 10 to 15 mm. long. The total activity of the radium emanation is nearly equal (90 per cent.) to that of the radium from which it was obtained. The active deposit loses about one-half its strength in one-half hour and is of limited practical use. The emanation decreases in strength about one-half in four days and has many advantages. The tubes of emanation may be embedded and retained in the tissues or arranged in special boxes, packs, in paraffin, dental modelling compound, rubber tubes, or other devices.

The dosage in millicurie hours of the emanation is estimated by multiplying the measured quantity of emanation by the factor 132.

Filtration.—Silver, 0.5 mm. thick, absorbs all but the hardest rays (gamma and beta). Lead, 2 mm. thick, is used for heavy surface filtration. Brass, 2 mm. or less in thickness, if combined with silver or platinum is also useful for heavy surface filtration to obtain homogeneous rays for penetration to a depth. Platinum, 1 mm. thick, will replace 2 mm. of lead, while 0.5 mm. is equivalent to 2 mm. of brass and is useful when the applicator must be of small size.

Distance.—To secure homogeneous raying and prevent injury to the skin from the softer rays, treatment with large applicators from a distance of 3 to 10 cm. may be used.

As the lethal radiation dose of normal cells is but little less than that of many tumor cells, metastatic lesions should be excised or destroyed by embedding radium needles or tubes of emanation directly in the growth. The tubes should be placed close enough together to destroy all malignant cells directly or by cross-firing.

Radiotherapy.—Squamous-cell cancer is much more resistant to radiation than basal-cell growths. Radiation damages the cell-nucleus (especially during mitosis), causes edema of the cell body and vacuole formation in the cytoplasm, and produces an obstructive endarteritis and a fibrosis of the lymphatic channels. Bare tubes or seeds of radium have a direct caustic action and cause necrosis of the adjacent tissues. There is no selective destructive action of the rays on cancer tissue, and the local resistance of the various tissues to the rays varies greatly. Surface applications are made by screened radium, or by seeds containing radium emanation, inserted under anesthesia. Larger or deeper areas are treated with radium packs or Roentgen rays, or both. If the tributary lymph-glands are involved, a block dissection should be done. Radium may be buried at suspicious outlying points. Underdosage may stimulate tumor growth, or be followed by an acquired immunity of tumor-cells to the rays. Overdosage favors malignant dissemination by destroying the resistance of the tissues. Properly used, radium produces a tissue medium unsuited for the development of carcinoma. In large dose the Roentgen ray produces anemia and cachexia of the animal, and reduces the resistance to malignancy. Radiation is most beneficial for surface carcinoma where two or three times the erythema dose or a cauterizing dose may be given. Usually the cancer cells remain potentially infective after being "rayed" and, therefore, should be excised or destroyed by knife or cautery. Eighty per cent. of basal-cell carcinomata are curable by

radiation. Prickle-cell carcinomas, especially of the cervix and mucous membrane, are more resistant, and should be treated by direct implantation of radium, or by excision or cautery destruction. The tributary lymphatic glands may be removed before or after the destruction of the primary growth. Irradiation for deep metastasis rarely is helpful; irradiation of the liver is of no value. Patients with cachexia and low resistance, or with extensive, widespread or metastatic growths, should not be treated by radiation.

In basal-cell carcinoma (*rodent ulcer*) the lymphatics are not involved, and need not be excised or radiated.

Blair Bell's treatment of carcinoma is based upon the influence of lead upon the chorionic villi in pregnancy, and the apparently reduced incidence of cancer in lead workers. Lead in finely divided colloid form (made up with gelatin) is injected intravenously, the dosage being 0.1 gm. of metallic lead, which is repeated at intervals until about 0.6 gm. have been given. It should not be used in nephritics, and the urine and blood should be constantly studied. Stippling of the red cells is the most important evidence of toxicity. One or two such cells to a field indicate the temporary discontinuance of the metal, as does also albuminuria. A number of deaths have followed the treatment and its value is questioned. In cancer of the mouth, and for metastatic lesions, the results have not been favorable.

Constitutional Treatment.—A general roborant treatment with fresh air, sunshine, an out-of-doors life, full nutrition, the correction of acidosis, and the avoidance of a high protein diet should be used. If the patient is anemic, transfusion may be of transient benefit. Absence of leukopenia and presence of lymphyocytosis are favorable. The tissue resistance is inversely as the number of plasma-cells present (Parkhurst).

Increase of Immunity.—Injections of an emulsion of a corresponding type of tumor (Coca) or cancer extract may be of occasional value. Some relief follows the injection of animal proteids—*ascitic fluid, tissue extracts, fetal emulsion* (Fischira)—in a small percentage of the patients. Tuberculosis is associated with cancer in 9 per cent. of patients. Where syphilis is present, an active antisyphilitic treatment may be dangerous. Diathermy reduces the painful reaction following radiation or extensive resection. A rapid retrogression of the tumor, from treatment or other cause, may overwhelm the body with toxic substances and cause death.

Palliative Operation.—By overcoming local irritation and obstruction—by gastrostomy, gastro-enterostomy, jejunostomy, enterostomy, or colostomy—the tumor may show reduction in size and life be prolonged.

Vascular ligation is used to starve the tumor cells (Dawbarn): Ligation of the internal iliac arteries, a short distance from their points of origin, is used for carcinoma of the uterus; of the carotid, for carcinoma of the face and neck; the inferior mesenteric artery, for carcinoma of the rectum.

Chordotomy and the injection or division of sensory nerves or the posterior nerve-roots have been used to relieve the pain from carcinoma.

CYSTS

Embryonic cysts (*dermoid cysts*) are cysts of epiblastic origin containing the elements of skin, including epithelium, sebaceous material, hair, and teeth.

1. **Sequestration dermoids** originate from misplaced epiblastic tissue, and are found along the lines of fusion in embryonic development, especially the facial and branchial clefts, the medial and lateral palpebral commissure, sides of the nose, angles of the mouth, and pinna of the ear.

2. **Tubulodermoids** have their origin in persistent fetal ducts: (a) *Lingual dermoids*, from the upper part of the thyroglossal duct; (b) *branchial dermoids*, beneath the deep fascia of the neck, from the thymic duct or brachial clefts; (c) *rectal dermoids* usually arise between the rectum and sacrum, from the postanal duct; (d) *urachal dermoids*, from the urachus; (e) *ovarian dermoids* may arise from parthenogenesis, or the inclusion of a fertilized ovum in the body of the fetus.

Fig. 81.—Small dermoid at the base of the nose with projecting hairs.

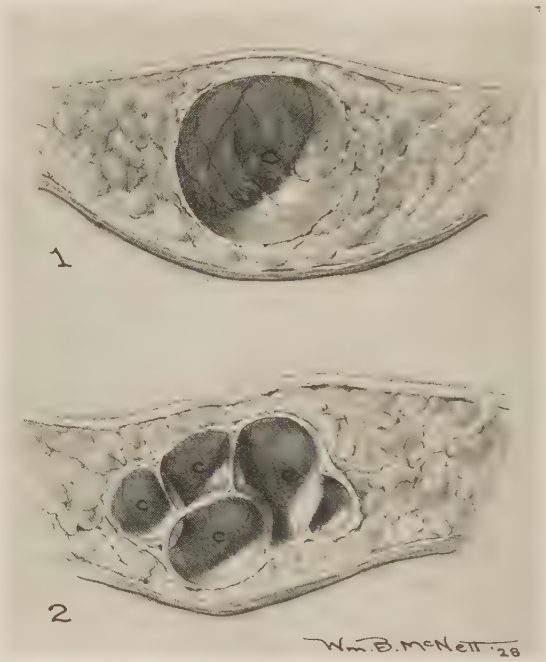


Fig. 82.—Cysts: 1, Monolocular; 2, multilocular.

3. **Teratomas or mixed tumors** arising from a conglomerate mass of fetal tissue, as from *inclusio fœtus in fœtu*, chiefly occur in the sacrococcygeal region.

Acquired cysts include: 1. Retention cysts due to—(a) obstruction of ducts or tubules of glands, which are dilated by the retained secretion as of sebaceous glands (*comedo*, *atheroma*, *sebaceous cyst* or *wen*); (b) obstruction of sweat-glands (*milium*); (c) of the kidney, cysts occurring in chronic interstitial nephritis; (d) retention of milk in the mammary gland (*galactocele*); (e) retention of semen in the epididymis (*spermatocele*); (f) obstruction of the salivary ducts (*ranula*); (g) obstruction of the fallopian tubes (*hydrosalpinx*); (h) obstruction of the ureter (*hydronephrosis*); (i) dilatation of alveoli of ductless glands (as the thyroid).

2. **Exudation cysts** are formed from the accumulation of fluid (a) in spaces without normal outlet, as in prepatellar bursitis ("housemaid's knee"), bunion,

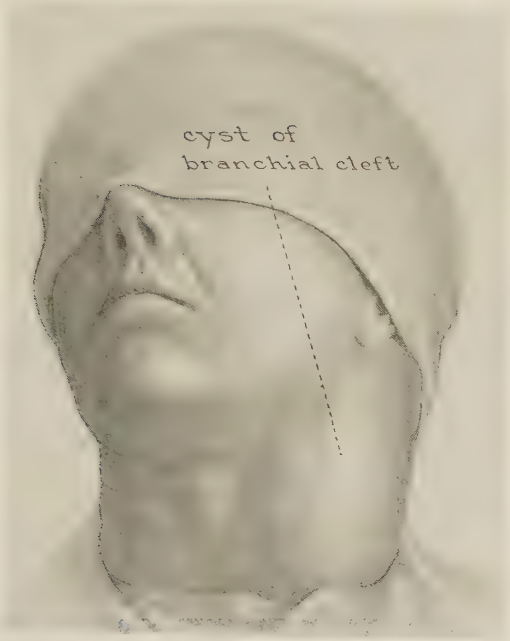


Fig. 83.—Branchial cyst of the left side of the neck.

Fig. 84.—Osteitis fibrosa cystica (bone cyst of the humerus) with slight bending of the shaft. (Roentgenogram by Dr. G. C. Bird.)

ganglion, hydrocele; (b) in the remnants of fetal structures, as *tubulocysts* (in urachus, parovarium, Gärtner's duct, brachial cleft, thyrolingual duct, omphalomesenteric duct, postanal duct).

3. **Colliquation cysts** (*liquefaction cysts*) are formed by the liquefaction of solids and occur in the brain from injury and in tumors. They contain serous, puriform, mucous, or colloid material.

4. **Parasitic cysts** are produced by the Trichina, Tænia solium (*Cysticercus cellulosæ*), or Tænia echinococcus (*hydatid cysts*).

Fig. 85.—Hydatid cysts in the anterior abdominal wall following operation for hydatid disease of the liver.

Treatment is the excision of the cysts and cyst walls. For certain retention and exudative cysts aspiration is effective, with or without the injection of a sclerosing substance, as a solution of iodin or phenol.

Part II

THE SURGERY OF SYSTEMS

CHAPTER XIV

THE BONES

Congenital total hemihypertrophy (*hemimacrosomia*), a rare developmental condition with asymmetrical enlargement of one-half or a part of one-half the body. The hand, foot, leg, or arm is enlarged, and of the masculine type, with excessive hair, greater muscular development, and more rapid growth of nails than that of the opposite side. It differs from acromegaly in being unilateral. A limp may be caused by the increased length of one leg. The enlargement is permanent, but does not progress after adolescence. Other congenital anomalies of bone are considered in Chapter LVIII.

Treatment.—High shoes should be adjusted to equalize the length of the two legs. No method of arresting the overgrowth is known. Reduction in size of the part by operation is occasionally desirable.

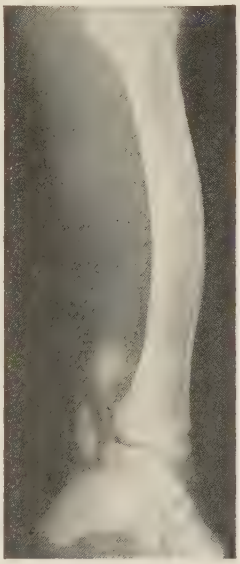


Fig. 86.—Congenital absence of the fibula, anterior bowing of the tibia (Dr. A. D. Kurtz).

CONDITIONS CHARACTERIZED BY IMPERFECT DEVELOPMENT OF BONE

Rickets (Rachitis).—A metabolic disease of infancy, due to lack of vitamins A and B, characterized by the absorption of developed bone and the overdevelopment of lime-deficient bone.

Pathology.—The epiphyses are enlarged, being wider and thicker than normal. The cartilage cells are increased in number and the columns irregularly arranged. There is excessive vascularity, deficient calcification, defective and irregular formation of true bone, excessive deposit of soft osteoid tissue, thickening and vascularity of the periosteum, increase of red cells and diminution of myelocytes in the medulla, with as much as 50 per cent. reduction in the contained lime-salts of the bone. With recovery the bone becomes abnormally hard and brittle, and deformities become fixed.

Symptoms.—Children between the ages of three months and three years develop mental irritability, and show profuse sweating, delay in sitting, walking and dentition, a tendency to bronchitis and diarrhea, a protuberant abdomen, and palpable liver. The bony changes include beading of the ribs at the costochondral epiphyses (*rickety rosary*), vertical groove at the junction of the ribs and cartilage (*pigeon breast*), a transverse groove from the xiphoid cartilage out-

ward (*Harrison's sulcus*) with the costal margins turned upward, from traction of the diaphragm. The sulcus may also result from inspiratory obstruction, as by enlarged tonsils. The epiphyses are enlarged, especially at the lower end of the radius and of the tibia and fibula. The head is enlarged, square, lengthened anteroposteriorly, and flattened on the vertex (*caput quadratum*). There is delay in the closing of the fontanels, bossing of the parietal eminences (*hot-cross-bun head*), cranial tabes; bending of the long bones, especially the lower third of the tibia, an anterior curve of the femur or, more rarely, coxa vara or genu valgum. The ligaments are relaxed, with a tendency to kyphosis, anterior and posterior flattening of the pelvis, dwarfing, and greenstick fracture. The muscles are weak.

Prophylaxis.—Breast feeding, ample supply of vitamins A and B by cod-liver oil and orange juice. Exposure to sun and fresh air. Rest and splinting or braces while the bones are soft. Residual deformities remaining after the bones have hardened may require osteoclasis, osteotomy, or osteoplasty.

Adolescent rickets (*rachitis adolescentium*) occurs between the ages of nine and seventeen. The condition may be a recrudescence from childhood. There is malaise, weakness, pains in the bones, softening and deformity of ossifying junctions, especially in the knee-joints. The joints (including the knees, wrists, and ankles) are swollen, and the costochondral junctions enlarged. Genu valgum may rapidly develop.

Treatment.—Fresh air and sunshine, an ample diet with free use of vitamins, and appropriate braces or other support to prevent deformity.

Infantile scurvy (*scurvy rickets, scorbutus, Moeller-Barlow disease* [Moeller, 1859; Barlow, 1883]) occurs in children under two years of age, from dietetic deficiencies; is characterized by acute onset, with pyrexia, debility, pain on movement, and hemorrhages under the periosteum and in the subcutaneous tissues.

Etiology.—A deficiency disease, most frequently occurring between the sixth and twelfth months.

Symptoms.—Fever, with tender swellings from subperiosteal hemorrhages over the long bones, especially the femur. Subcutaneous ecchymoses and hemorrhages occur in the skin, orbit, conjunctiva, and from the mucous membranes.

Epiphyseal separation or, more rarely, fracture of the bone-shaft may follow. There is formation of the bone from the raised periosteum, with enlargement.

The *Truemmerfeld line* is the zone of metaphyseal degeneration with deficient calcium deposit.

Treatment.—Sunshine, regulation of diet, orange juice, cod-liver oil, meat juice, green vegetables, breast milk, or carefully modified cow's milk. Deformities and fractures should be treated as indicated in Chapters XV and LVIII.

Fragilitas ossium (*osteopsathyrosis, Lobstein's disease* [Lobstein, 1833], *osteogenesis imperfecta*) is an abnormal brittleness of bones, with a tendency to fracture.

Classification.—1. Congenital form: *Osteopsathyrosis congenita.*

2. Hereditary type: *Hereditary hypoplasia of the mesenchyme.*

3. Non-hereditary, congenital type: (a) *Osteogenesis imperfecta;* (b) *osteopsathyrosis with white sclera;* (c) *osteopsathyrosis with blue sclera.*

4. Non-hereditary, acquired type: *Osteosclerosis fragilis generalisata, marble bones,* or *Albers-Schönberg disease.*

5. Senile: *Osteoporosis.*

6. Disuse, trophic cause, or pressure.

Fetal osteogenesis imperfecta (*osteopsathyrosis congenita, annular rickets*) is a disease arising *in utero*, due to defective formation of bone from both membrane and periosteum, with abnormal brittleness and a tendency to multiple fracture.

Pathology.—The body is well proportioned, but the bones are soft or brittle, with a tendency to multiple intra-uterine fracture and to still-birth. The skull shows frontal and supra-orbital prominences; a downward tilting of the axis of the orbit, ear, and auditory canals; and an underhung jaw. Callus formation is active, and early union occurs after fracture.

Brittle Bones and Blue-sclera Syndrome (Spurway, 1894), **Hereditary Hypoplasia of the Mesenchyme** (Key, 1926).—An hereditary defect characterized by brittleness of bones, china-blue sclera, short stature, hypermobility of joints, weakness of fibrous structures, and, after adolescence, progressive deafness.

Etiology.—Only family members having blue sclera show bony defects. The disease may be absent in the parents, although present in about half of the patient's children. The hereditary factor is dominant—inherited directly from the affected parents with the skipping of a generation.

Symptoms.—The sclera may be clear china blue, slate blue, or grayish blue; the anterior portions being darker, from an abnormal transparency of the sclerotic coat permitting the blue uvea to shine through. Embryotoxon may be present. The slight blueness of the sclera often present in anemia, tuberculosis, and heart disease should be differentiated. The stature usually is below normal; the bones are short and slender. The skull is of the osteogenesis-imperfecta type. Otosclerotic deafness develops in early adult life, and later is complicated by labyrinthine disease or nerve deafness. The fractures are not usually present at birth, as in osteogenesis imperfecta, are not spontaneous, and occur chiefly in the eighth and ninth years. The average number of fractures is 7, although up to 60 fractures have been reported. The long bones, especially of the lower extremities, are most frequently affected; occasionally the mandible, ribs, patella, pelvis, and the fingers; rarely the bones of the face, the upper jaw, scapula, sternum, metacarpals, tarsals, and metatarsals. The *fractures* are usually simple, transverse, or oblique, and not of the greenstick variety, and occur through the diaphysis, near the epiphysis. No epiphyseal separation or fracture of the neck of the femur has been recorded. Compound fractures are rare. Pain and swelling is usually slight and, as a rule, fairly firm consolidation occurs in from four to eight days, with little callus, deformity, or tendency to refracture. Deformities occur only from malunion. The associated hypotonicity and hypermobility of joints result in frequent sprains and dislocations.

Roentgen-ray study shows eccentric atrophy of bone, with thin cortex and wide marrow cavity; or concentric atrophy, with slender diaphysis, rather thick cortex, and narrow marrow cavity. Dentition is, as a rule, normal. The calcium and phosphorus contents of the blood were normal in Key's case. The condition is a developmental rather than a metabolic disorder.

Diagnosis is made by the peculiar, bluish sclera present in one or both parents. Osteogenesis imperfecta is not known to be hereditary; numerous fractures are present at birth or in infancy, and most of the patients die in early life.

Acquired Osteopsathyrosis.—The fractures occur in childhood and are usually not numerous. The patient may or may not have a blue sclera, "*marble bones*" or *Albers-Schönberg disease.*

Prognosis.—The fractures unite quickly, and the tendency to fracture usually disappears after puberty, although the brittleness may persist into late adult life.

Treatment.—Empiric: No specific treatment is known.

Marble bones (*Albers-Schönberg disease*) is a rare condition of abnormal brittleness of bone, usually developing in childhood, with failure of bone formation from membrane or periosteum.

Pathology.—The bony cortex is thin, and the bones brittle and easily fractured. The formation of bone from cartilage is unaffected, and there is no dwarfing.

Symptoms.—Fracture occurs from slight violence, but with no effect upon the general health. Early bony union follows. The tendency to fracture usually disappears after the age of thirty.

Treatment.—Symptomatic: Phosphorus, vitamins, calcium, and parathyroid may be tried.

Senile osteoporosis and **osteoporosis from disuse or trophic cause** occur in chronic wasting diseases, in cachexia, rickets, scurvy, phosphorus poisoning, insanity, general paresis, locomotor ataxia, syringomyelia, hemiplegia, anterior poliomyelitis, and paralysis of peripheral nerves.

Bones may be weakened by local pressure or disease, as from osteomyelitis, cysts, benign or malignant tumors, tuberculosis, and syphilis.

Osteomalacia (**Mollities Ossium**).—A softening of bone with a tendency to bend and fracture, occurring chiefly in pregnant and puerperal women.

Etiology.—The disease occurs chiefly in women during pregnancy and lactation, only 8 per cent. occurring in men or boys. It is a rare disease, neither congenital nor hereditary, with endemic foci, on the Rhine and in Switzerland.

Pathology.—The bone decalcifies and becomes soft and light, the Haversian canals dilate, the bone-corpuscles are large, irregular, and crowded together, the structure of the lamellæ being obscured. The bone-marrow is vascular, with hemorrhages and cyst formation. There is newly formed osteoid tissue, but with deficient calcification and thinning of the trabeculæ. Osteomalacia affects the pelvis, spine, thorax, and extremities.

Symptoms include weakness, rheumatic pains, with bending of the long bones of the legs, waddling gait; progressive deformity, as narrowing of the anterior pelvis, spinal curvature; and finally fracture of legs, sternum, or ribs. The urine may show an increase of calcium.

Prognosis.—The disease may be arrested with the termination of pregnancy and lactation, or continue to a fatal issue after one to ten years.

Treatment.—Avoidance of pregnancy and lactation, bilateral oöphorectomy, or a panhysterectomy, with the internal use of phosphorus and adrenal extract. The administration of calcium seems to be of little value.

Achondroplasia (*chondrodystrophia fœtalis*) is a congenital abnormality of bone formation from cartilage, with resulting deficient growth in long bones; the subjects having long bodies, large heads, and short limbs—*achondroplastic dwarfs.*

Pathology.—Deficiency of endochondral ossification in the epiphyses. The line of ossification is straight and narrow, the cartilage cells being irregularly arranged and scanty, with excessive ingrowth of connective tissue from the periosteum, and retarded or premature ossification of the epiphyses. There is normal periosteal bone formation. The stature is short, 3 to 4 feet; the extremities very short, especially the femur and humerus, but the trunk about normal in size. The head is large, with small face and pug nose; the fingers diverging (*trident hand*); the sacrum tilted forward with pelvic contracture, giving apparent lordosis, a protuberant abdomen, and bowing of limbs from abnormal articulation, without curving of the shaft. The patients are strong, virile, mentally quaint, and sexually precocious. They served as jesters for kings in olden times, and are now frequently seen as acrobatic dwarf clowns on the stage or in the circus ring.

Etiology.—Undetermined. The condition begins between the third and six months of fetal life, affects both sexes, involving only bones formed in cartilage. Possibly it is an intra-uterine deficiency disease or fetal rickets. It differs from rickets in being aplastic and not hyperplastic, and in the excessive ingrowth of connective tissue. There is no evidence that it is due to hereditary syphilis or error in internal secretions. The bones are normally hard, without softening. While many of these children are born dead, the vitality and general health of those who survive are excellent after the first year.

Treatment.—A full supply of vitamins is suggested.

CONDITIONS CHARACTERIZED BY OVERGROWTH OF BONE

Acromegaly.—A disease of young adults due to disease of the anterior lobe of the pituitary gland, characterized by bony overgrowth, affecting the mandible, feet and hands, and often associated with gigantism. (See Diseases of the Pituitary Gland, page 494.)

Osteitis Deformans, Paget's Disease of Bone (Sir James Paget, 1877).—A chronic progressive, symmetrical disease affecting the long bones, skull, and spine; with early hyperemia, bone absorption and softening, followed by bending, thickening, sclerosis, and a tendency to sarcomatous change.

Pathology.—First the marrow becomes vascular, and the bone, rarefied and partially decalcified, bends under pressure. Later excessive bone formation occurs, with calcification and sclerosis. The bones become elongated, heavy, thick, rough, uneven; the marrow cavity and diploë may be obliterated. The skull is enlarged and eccentrically thickened, with obliteration of sutures. The facial bones are not affected. Late fracture, acute softening, bending, or rapid thickening is suggestive of sarcoma.

Etiology is obscure. It is more frequent in men and in persons past fifty years of age.

Symptoms develop slowly and insidiously, with slight fever and dull, aching pains in the back or limbs, enlargement of the long bones and the skull, and curv-

ing of the spine and tibia or other long bones. The stature is reduced, the legs separated, rotated out, curved forward and out, and slightly flexed at the knee. The trunk is short and the clavicles thickened. The spine is kyphotic, especially in its upper part; the head and neck are carried forward, the thorax deformed, and the arms appear unduly long, but usually are less affected than the legs. The appearance resembles that of an anthropoid ape. The muscles tend to waste. There is a transverse abdominal sulcus. In some cases the skull is chiefly affected, the roentgenogram showing thickening and round, knobby masses of bone between the inner and outer tables or, at times, on the outer table.

Fig. 87.—Bone cyst of humerus. (Roentgenogram by Dr. S. C. Bird.)

Prognosis.—Paget's disease continues for years, the patient going about in fair general health despite the deformity. The thickening of the skull and encroachment on the cranial cavity cause headache, pressure symptoms, or mental change. Repeated fractures of long bones may occur and, with acute softening or enlargement, suggest sarcomatous change.

Treatment.—No effective treatment is known. Parathyroid, thyroid, and calcium should be tried.

Osteitis fibrosa (*osteitis fibrosa cystica, von Recklinghausen's disease, cystic disease of the bone*) occurs in the young, with the development of fibrous tissue and cysts in the shafts of the long bones.

Etiology.—Usually develops before the age of twenty, more frequently in males. It may follow moderate trauma.

Pathology.—Involves chiefly the shaft of humerus, upper end of femur, or the fibula, with the development of single or multiple cysts having a thin, leathery lining. The shaft is expanded, the cortex thinned. The epiphysis is rarely involved.

Cysts.—Dense, white fibrous tissue and cellular masses containing giant-cells are formed in the bone. Usually with single focus, the process may occasionally affect a number of the long bones, the phalanges, or the skull (von Recklinghausen's disease). The jaws are not involved.

Symptoms.—A slow and gradual enlargement of the shaft of a long bone, with a tendency to fracture or, more rarely, to bend. As a rule there is little or no pain or constitutional symptoms, and often the disease is not recognized until spontaneous fracture or bending occurs.

Diagnosis.—A painless thickening of the bone, without evidence of local inflammation or venous congestion. Metastasis does not occur. Joint function is unimpaired. The condition is often unrecognized until a roentgenogram is taken. Roentgenograms show cystic areas in the medulla, separated by striations and trabeculations, with bulging and thinning of the cortex, but without periosteal involvement.

Prognosis.—Favorable. Spontaneous ossification and healing occurs in 3 per cent. Relief follows operation in other cases. Fractures usually unite.

Treatment.—(1) Roentgen-ray treatment; (2) operative removal of bony shell, curettage, and application of pure phenol; (3) introduction of a bone-graft.

Leontiasis ossea (*lion face*) is a progressive hyperostosis of the cranial and facial bones, with a progressive formation of dense new bone. It causes deformity and pain from pressure due to occlusion of the foramina of the skull, the orbit, nares, and mouth.

Pathology.—The enlargement may be diffuse, irregular or nodular, the result of: (1) Chronic periostitis or creeping periostitis, spreading slowly from bone to bone. (2) Diffuse osteitis of the bones of the face and skull, which may (a) affect all cranial and facial bones, or (b) be localized to one or more bones.

Etiology.—A disease of young adults, usually first noticed about the age of thirty. The condition also develops before birth, in childhood, or at puberty.

Symptoms.—A slow and progressive enlargement of the facial bones, with later pressure symptoms and hideous deformity. The deformity includes prognathism, protruding upper jaw, and exophthalmus—the eyes being pushed forward and downward from pressure by intra-orbital excrescences. There is contraction of the orbits and nasal fossæ; pressure on vessels, nerves, and ducts, with headache, dizziness, cerebral symptoms, convulsions, paralysis, mental retardation and psychosis; bulbar symptoms; involvement of special senses, with choked disk and retinal atrophy, deafness of the sclerotic type, anosmia, and dacryocystitis from stenosis of the tear-duct.

Diagnosis.—The age, progressive nature, localization of the disease to the bones of the face and skull, and the secondary encroachment upon the bony cavities and foramina differentiate leontiasis from acromegaly and Paget's disease. Tumors of bone are more localized, and show a roentgenologic structure different from that of the dense bone in leontiasis.

Prognosis.—The bony hyperplasia continues for twenty to thirty years, the patient dying from pressure upon the brain, important nerves, or from intercurrent disease.

Treatment is palliative. The bone formation does not recur after surgical excision, but, owing to the extent of the disease and density of the bone, operations usually are unsatisfactory.

Hypertrophic pulmonary arthropathy is characterized by clubbing of the terminal phalanges and enlargement of the bones of the extremities, secondary to thoracic disease.

Clubbing of the Fingers (Hippocratic Fingers).—The terminal phalanges are enlarged, clubbed, and rounded; the nails enlarged and convex, the skin is shiny, and the toes may be involved.

Etiology.—Congenital heart disease or disease of the lungs or pleura precedes the bony changes.

Symptoms.—A painless, progressive enlargement of the phalanges. Apart from stiffness or tenderness, there is no associated evidence of inflammation. The condition tends to be permanent and progressive.

Treatment is that of the underlying thoracic condition.

Caries of Bone.—Molecular death of bone; may be simple, septic, tuberculous, or syphilitic.

Varieties.—(1) *Caries sicca*—occurring without suppuration. (2) *Caries suppurativa*—with suppuration. (3) *Caries fungosa*—with exuberant granulations. (4) *Caries necrotica*—associated with necrosis of minute portions of bone.

Etiology.—*Necrosis of bone* is due to periostitis, osteitis, osteomyelitis, or injury. Toxic necrosis is caused by phosphorus or mercury, often in association with bacteria.

Senile necrosis (*quiet necrosis*) follows traumatism, probably with a mild associated infection.

Treatment.—Evacuation or removal of necrotic or puriform collections, and treatment of any underlying constitutional condition.

INFECTIONS OF BONE

Infections of bones involve: (1) Periosteum, *periostitis;* (2) bone substance proper, *osteitis;* and the (3) marrow cavity, *osteomyelitis.*

Acute periostitis is rather unusual, except as a part of an associated osteitis or osteomyelitis. It occurs in typhoid fever, syphilis, and other infections. There is local pain and tenderness, followed by edema of the overlying soft tissues, swelling, and, later, redness. A subperiosteal abscess often forms, and the underlying bone undergoes necrosis.

Treatment.—1. *Prophylactic:* The skin is punctured by a tenotome which is carried through the periosteum, and the membrane is freely incised. The small puncture is covered by a layer of yellow precipitate ointment, and a bandage applied. If this is done early, the pain is often immediately relieved, and prompt recovery follows.

2. Abscess formation may strip the periosteum from the underlying bone, and lead to extensive necrosis. The treatment is *free incision* and *drainage;* followed later by the removal of dead bone, and the treatment of any associated osteitis or osteomyelitis.

Chronic periostitis occurs in the dystrophies, and from bruises and contusions of bone; from wounds, chronic inflammation of the overlying soft tissues, and from chronic infections, as syphilis.

Pathology.—There is periosteal thickening, formation of nodes, and (in syphilis) subperiosteal gummata.

Symptoms include: Dull, aching, boring pain, worse after exertion and at night (*osteocopic pain*); local tenderness on pressure; deep swelling, or thickening of the bone, and periosteal hyperplasia, shown on the roentgenogram.

Treatment includes the correction of any underlying diathesis, puncture or incision of the thickened periosteum, or, if an abscess has formed, incision and drainage.

Osteitis rarely occurs apart from an osteomyelitis or a periostitis.

Acute osteomyelitis is an acute septic infection of the bone-marrow, usually due to the *Staphylococcus aureus.*

Etiology.—Osteomyelitis occurs in children between six and sixteen years of age, and in boys rather than girls. It frequently is localized or excited by contusion or exposure to cold or wet. Associated debility or malnutrition is

common. A preceding exanthema, or local infection with pustules or furuncles, may act as the focal cause of the infection.

Pathology.—A hematogenous infection by the *Staphylococcus aureus*, which colonizes in the metaphyses or juxta-epiphyseal areas of the long bones, particularly the tibia, femur, and ulna. The tibia is involved in 42 per cent.; the fibula, in 3 per cent. (von Bruns).

The staphylococcus lodges in the fine capillaries of the metaphysis, and causes secondary suppuration in the medullary cavity, with tension and intense septic phenomena. This is followed by osteitis, spreading of the infection to the cortex, through haversian and Volkmann's canals, formation of a secondary abscess under the periosteum, and separation of the periosteum from the bone. With rupture or perforation of the periosteum, deep spreading abscesses form in the soft tissues. The disease rarely spreads through the cartilage of the epiphysis to the adjacent joints. However, if the epiphyseal cartilage lies within the joint

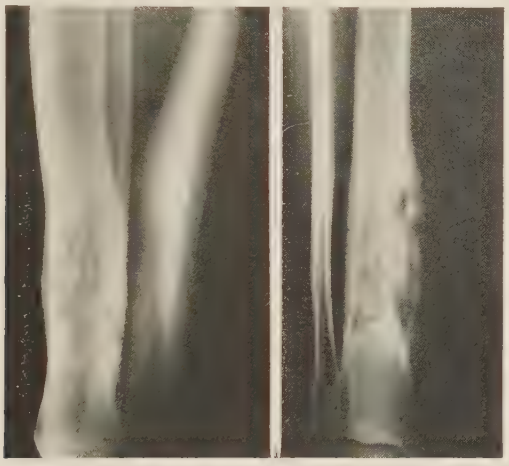


Fig. 88.—Osteomyelitis of the lower third of the tibia (Dr. A. D. Kurtz).

capsule (as with the hip or elbow), suppuration may extend into the joint; in infants the epiphysis, consisting of thin cartilage only, may be perforated; or infection may reach the joint by extension through the soft tissues.

1. If the infection is mild and resistance good, the inflammatory process may be limited to an abscess (*Brodie's abscess*) in the cancellous tissues surrounded by a dense, thickened layer from osteosclerosis.

2. The bone—separated from its periosteal and endosteal blood-supply, and with its intrinsic vessels occluded by inflammatory products—undergoes extensive necrosis, followed later by *sequestration* or the separation of the dead bone. New bone (the *involucrum*), formed from the deeper layer of the periosteum, surrounds the sequestrum, and has openings or *cloacæ* through which the pus escapes. The sequestrum may consist of the entire diaphysis. With the removal or expulsion of dead bone and the subsidence of infection, the sinuses close and the involucrum gradually assumes the contour and function of the old bone.

3. In *medullary osteomyelitis* the medulla first becomes inflamed, the veins

thrombosed, and pyemia may follow. The haversian vessels are infected, and exudation and pressure lead to arrest of circulation and necrosis of bone. The epiphyses are less affected because of their independent blood-supply, absence of periosteum, and separation from the shaft by a comparatively avascular zone of cartilage.

Symptoms.—*Clinical Picture:* A boy, debilitated or convalescent from a recent illness, is taken violently ill after exposure to cold or wet, or after slight injury of a long bone. He has a chill, followed by a temperature of 103° to

Fig. 89.—Staphylococcic osteomyelitis of the tibia in a boy of eleven years, showing abscesses and sequestræ in the bone.

106° F., rapid pulse, leukocytosis, and often delirium and stupor. The symptoms are those of an acute severe general infection, and the boy makes little or no complaint of local pain or tenderness until several days have elapsed. In the early stage, however, although there is no local swelling or edema, prolonged pressure over the affected bone causes the patient to cry out with pain (Nichols). Later there is local tenderness over the affected bone, followed by swelling, edema, and finally redness of the overlying skin, and fluctuation from the spread of the pus in the soft tissues.

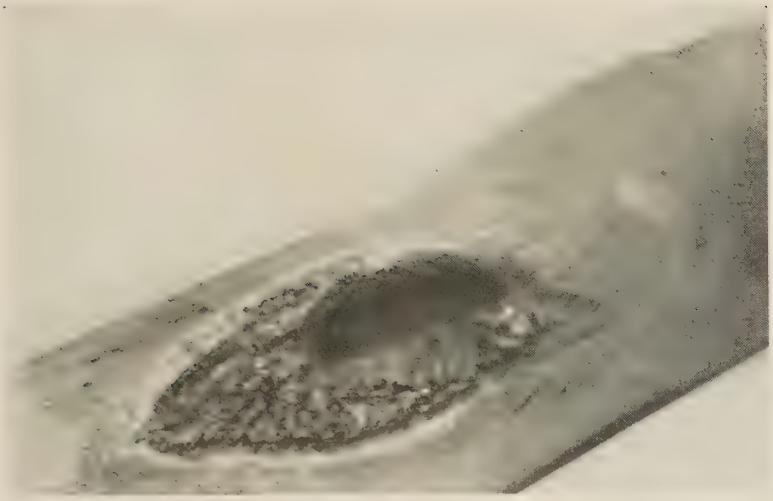


Fig. 90.—Large cavity following operation and Carrel-Dakin treatment for traumatic osteomyelitis of the tibia.

Fig. 91.—Method of contouring bone for chronic septic osteitis and osteomyelitis. The contoured surfaces are covered by living muscle. After healing has occurred the bone gradually thickens and finally approximates its normal shape and strength. 1. Removal of infected bone and sequestræ by chisel. 2, 3. Contoured bone with shallow, saucer-shaped surface. 4, Use of adjacent living muscle to cover surface of bone.

Complications.—(1) *Pyemia:* A number of bones, including the ribs and clavicle, may be infected; cutaneous abscesses form, or secondary involvement of the pleura or other serous cavities occur. (2) *Acute arthritis.* (3) Extensive *necrosis* of bone. (4) *Destruction* or *stimulation of epiphyses*, with shortening or lengthening of the limb. (5) Secondary *parenchymatous* and *amyloid disease* from prolonged suppuration.

Diagnosis is to be made from rheumatism, acute general infection, or pyemia. A chill, high fever, and delirium of acute onset in a child suggest a possible medullary infection, and the long bones should be carefully examined. If local tenderness is found on prolonged pressure, or edema or thickening of the deep tissues detected, the patient should immediately be treated for osteomyelitis. Roentgenograms in the early stage are rarely of value.

Fig. 92.—Bone contoured for an osteomyelitis following comminuted compound fracture of the femur.

Prognosis is grave. The patient within a few days may die of pyemia, after weeks or months from septic complications, or continue with a suppurative osteitis and sinuses for one to several years, before complete healing is obtained.

Treatment.—First Stage—*Localized Metaphysitis:* The skin should be punctured to the bone, one or several holes drilled into the metaphysis and medullary cavity with a gimlet, and a dressing of yellow oxid-of-mercury ointment applied to the overlying skin. This will often promptly arrest the process. The patient should be kept quiet, in bed, the limb elevated and immobilized, mixed staphylococcic vaccine injected subcutaneously, elimination encouraged, and tincture of the chlorid of iron, orange juice, cod-liver oil, and a nutritious liquid diet given.

Second Stage—*Purulent Osteomyelitis:* If the process has continued over three days and edema of the soft tissues and local pain are marked, a free incision should be made through the periosteum, and the bone guttered by a sharp chisel and gouge. Pus beneath the periosteum and in the medullary cavity is permitted to escape, the incision left freely open and dakinized, or packed with iodoform gauze wet with 1 : 4000 sublimate solution.

Curetting or other meddlesome measures or dry dressings should not be used in the stage of acute infection. In the later dressings free drainage should be provided. Sinuses should not be occluded or plugged by gauze, but filled (by syringe) with a paste of 50 per cent. red iodid of bismuth in petrolatum.

Third Stage—*Sequestration:* After three or more months have elapsed, and the tissue resistance has been regained, sequestration and closure may be attempted by:

1. The *zinc-chlorid method* (Babcock) (see page 272).

2. The *Mosetig-Moorhof method:* (a) All dead and diseased bone is carefully removed by sharp chisel and curet. (b) Hemostasis being complete, the bone cavity is thoroughly dried, preferably by hot air. (c) The bone cavity is accurately filled with the Mosetig-Moorhof bone plomb or wax—consisting of iodoform, 40 parts; oil of sesame, 60 parts; white wax, 60 parts. (d) The soft tissues are carefully united over the bone without drainage. The bone plomb is very gradually absorbed, and replaced by new bone. If infection occurs, the wound is freely opened and drained, and the procedure may then be repeated at a later date.

The roentgenogram is valuable in showing the degree of sequestration and the time for operation.

Acute septic, traumatic osteomyelitis follows septic compound fractures, amputation, and operations upon bone.

Symptoms are inflammation and suppuration of the wound with fever, rigor, even pyemia. The bone, separated by pus from the adjacent soft tissues, becomes white, yellow, and bloodless. After months the sequestrum, eroded and separated by the osteoclasts, finally loosens and may be extruded.

Treatment.—Early free incision and drainage, including drainage of the medullary cavity. After several months the loosened sequestrum is removed, with primary or secondary closure.

Fig. 93.—Macewen's chisel modified.

Fig. 94.—Bone gouge.

Fig. 95.—Babcock's retractor and periosteal elevator for operations upon long bones.

Typhoid osteitis (*osteomyelitis*) is a rather common sequel to enteric fever. Single or multiple lesions, involving the marrow or periosteum of chiefly the tibia and the ribs, occur after the sixth week of typhoid. The pain is vague, and increased by pressure, movement, and at night. Later there is swelling, redness, edema, and indistinct fluctuation, with the formation of plastic exudate or creamy or brownish pus. Occasionally spontaneous resolution follows.

Treatment.—In the plastic type, the use of typhoid and paratyphoid vaccine in progressive doses, with yellow-oxid ointment locally, may be followed by resolution. If pus forms, it should be evacuated by an incision through the periosteum and a dressing of bismuth paste used. As a rule this treatment is followed by rapid healing. At times an osteotomy or resection of the bone is necessary.

Circumscribed abscess of bone (*Brodie's abscess*) occurs chiefly in young adults, usually near the center of the metaphysis of the tibia, the upper and lower end of the femur, or end of humerus. There is a bone cavity filled with serum or pus, lined by a fibrous membrane with surrounding sclerosed bone, and a tendency toward obliteration of the adjacent medullary cavity.

The *staphylococcus* is the usual etiologic factor. The bone may enlarge, becoming thicker, heavier, and deformed.

Symptoms.—Boring, aching pain—referred to the center of the bone, aggravated by use, exacerbated at night—may continue for years with periods of relief. Other symptoms are tenderness on pressure or percussion, intermittent limp, hydrops of the adjacent joint, and local enlargement of the superficial veins and of the bone.

Roentgenogram shows a central defect surrounded by the dense shadow from bony sclerosis.

Treatment.—Osteotomy with removal of the walls of the cavity by gouge and chisel, and primary or secondary closure.

Quiet necrosis—*necrosis without suppuration* (Sir James Y. Paget)—should be treated by exploratory osteotomy, and removal of any necrotic bone.

Chronic osteoperiostitis usually begins as a periostitis, involving by extension the haversian canals and medulla, and producing a general sclerosis and thickening of the bone. It may be (a) diffuse, or (b) local.

Etiology.—It may follow trauma, rheumatism, or syphilis. Gummata may be present.

Symptoms.—Osteocopic pains (worse at night), the bones becoming heavy, nodular, then dense and sclerotic. The condition should be differentiated from sarcoma. A roentgenographic study is important.

Treatment is often unsatisfactory. It includes the free use of iodids (up to 30 gm. daily), the use of thyroid, Roentgen rays, drilling of the bone, guttering of the bone into the medullary cavity and contouring by the chisel, or, rarely, amputation, dependent on the gravity of the condition and the resistance to treatment.

Chronic non-suppurative osteitis (*Garré*) is a sclerosing, non-suppurative thickening of the cortex, with pain, little or no elevation of temperature, and, rarely, leukocytosis. The medulla is slowly obliterated, with little or no periosteal irregularity. The spindle-shaped, sclerotic diaphyses may be confused with a sclerosing sarcoma, but lacks the periosseous involvement. It may follow a furuncle or carbuncle. The general ossifying, hemorrhagic periostitis of scurvy may be differentiated by the history and the roentgenographic data.

Tuberculosis of Bone.—1. *Miliary tuberculosis* of bone is of very rare occurrence.

2. *Caseous tuberculosis* usually involves an end and the outer surface of long bones. There is necrosis and the sequestrum is often wedge shaped, with the base of the wedge toward the joint. In other cases there is a central sequestrum surrounded by a zone of tuberculous granulations, and this, in turn, by a zone of rarefying osteitis. The sequestrum may remain attached to living bone for a long period of time.

3. *Superficial caries* occurs under the cartilage of a joint or between the periosteum and underlying bone, with adjacent osteosclerosis and osteoporosis. The process rarely extends to a greater depth than 5 mm.

4. *Tuberculous periostitis* usually involves the ribs and vertebræ, producing caries in the underlying bone, with chronic abscesses that spread along the bone and fascial planes.

5. *Tuberculous osteomyelitis* or *epiphysitis* is seen in the phalangeal, costal, and carpal bones in children as *strumous dactylitis*. There is a localized fusiform swelling of a phalanx or metacarpal bone, with a tuberculous caseous process that breaks through the cortex. In adults, a diffuse thickening from periostitis and the formation of a central sequestrum is more common. Adjacent joints, tendon sheaths, and bones (especially those of the wrist and ankle) are involved by extension.

Fig. 96.—Spina ventosa, strumous dactylitis.

6. *Tuberculous caries sicca* is rare except in the shoulder-joint. Firm fibrous tissue forms on the surface, with progressive atrophy of the underlying bone associated with ankylosis and muscular atrophy.

7. *Diffuse osteosclerosis* may occur for some distance along the shaft of the bone, in the neighborhood of an old tuberculous process, the bone becoming dense and very thick.

8. *Diffuse softening* is rare, the disease spreading from one bone to the other, with enlargement of the medullary cavity and absorption of hard bone.

9. *Chronic, deep tuberculous abscesses* of bone are situated usually in the epiphyseal line, are lined by the so-called "pyogenic membrane," and surrounded by thickened sclerosed bone.

The cranial bones rarely become carious, with the formation of an external abscess; the vertebræ are affected by a central osteomyelitis or a superficial caries; the ribs, by periostitis, with abscess; and the long bones at the epiphyses, with caseation, necrosis, osteomyelitis, or chronic abscess. The diaphysis is seldom the seat of tuberculous periostitis, osteomyelitis, or chronic abscess. The pelvis is involved near the sacro-iliac joint, or, as an epiphysitis, at the crest of the ilium. The carpal, tarsal, and phalangeal bones are commonly affected by an osteomyelitis, with necrosis and caries. The os calcis, astragalus, and one phalanx may be separately diseased, although usually more than one bone is affected.

Fig. 97.—Saber-tibia from hereditary syphilis (Stokes).

Symptoms.—(1) *Pain*, which varies in proportion to the depth of the lesion and the pressure, rarely is severe. (2) *Enlargement* of the bone. (3) *Tension* and *distention* of the soft parts over the bone, the skin being pale (*tumor albus*). (4) *Abscess* forming with little inflammatory phenomena. (5) *Fever* is occasionally present, although often absent before the abscess breaks or becomes infected. (6) *Joint symptoms*—deformity. (7) *Muscle tension*, rigidity and immobility.

Treatment.—Rest, passive hyperemia, aspiration of abscesses, erasion or excision, an arthrodesis, or occasionally, when the disease has spread to several bones or joints, amputation. Movement and weight bearing favor extension of the disease and metastasis.

Syphilis of bones occurs as a symmetrical localized periostitis forming hard nodes, most commonly on the shaft of the tibia. There is dull, aching pain, worse when the part is warm, as at night. A diffuse hyperostosis of the diaphysis occurs, with dense bone formation and curving of shins (*saber-tibia*).

Tertiary Syphilis: *Gummata* are usually subperiosteal, and involve the cranium, especially the frontal and parietal bones. Firm nodular swellings first appear, which may fluctuate; the bone beneath presents carious destruction, with a circular excavation which very rarely perforates the skull. An osteoplastic periostitis at the margins, forming dense new bone, or an extensive sclerosis affecting the bones of the skull may be present. If the gumma breaks through the skin, a chronic foul ulcer results. The palate, maxillary bone, vomer, and ethmoid may be destroyed by submucous gummata, with resulting perforation of the palate and vomer and saddle-nose. Rarely the long bones are the seat of central gummata, which may lead to a spontaneous fracture with or without tendency to bony union.

Syphilitic lesions are usually multiple or diffuse, and chiefly involve the

periosteum. The roentgenogram shows a thickened cortex containing striated, mottled areas.

Treatment.—Active antisyphilitic treatment with large doses of iodids. Occasionally the evacuation and removal of necrotic tissue is necessary.

Blastomycosis (Blastomycetic Osteitis).—The parasitic yeast enters the body through the lungs or skin, from which it is carried by the blood-stream to the bone. The parasitic yeast-cell is round or oval, with a double refractile capsule containing spores. In bone, caries are produced and characteristic abscesses closely resembling tuberculosis, from which they differ in the excess of polymorphonuclear leukocytes and the Langhans type of giant-cell. Vertebral destruction with psoas abscess, abscess of the tibia, ribs, skull, and other bones and joints have been reported.

Diagnosis is aided by the associated blastomycetic lesions of the lungs or skin. The parasite is found in the pus or sputum.

Prognosis is unfavorable.

Treatment.—Heavy doses of potassium iodid, change of climate, radiation.

Coccidioidal granuloma, due to the parasitic mold, *Oïdium coccidioide*, is endemic in the San Joaquin Valley, California. The primary infection may occur in the lungs or skin, and the lesions suggest those of tuberculosis. The involved bones and joints become swollen, red, and painful.

Diagnosis depends on finding the characteristic parasite in the discharges or tissues. Differing from tuberculosis, the infected tissue contains many polymorphonuclear leukocytes and the Langhans type of giant-cell. The oïdium is spherical, has a double contoured, highly refractile capsule and no nucleus, and reproduces by endosporulation, the capsule rupturing and the spores escaping.

Prognosis unfavorable, death usually occurring in from a few months to several years.

Treatment.—Prompt resection and sterilization of the infected areas, or amputation. The actual cautery or zinc chlorid should be applied to the infected bone.

Echinococcus Cyst (Hydatid Disease).—Multiple echinococcus cysts occur in the articular ends of the long bones, the bodies of the vertebræ, and in the pelvis. The cysts tend to enlarge, the bone becoming expanded and the cortex perforated, and secondary suppuration and necrosis may follow. There is deep-seated osteocopic pain, enlargement of the bone, egg-shell crackling, irregular consistence, with secondary suppuration or fracture. From invasion of the vertebræ, spinal curvature and paraplegia may follow or, in the pelvis, a dangerous infection of the hip-joint.

Treatment.—The intravascular use of arsphenamin, with local excision or erasion of infected bone, after the injection of ether or 1 per cent. formalin solution to destroy the parasites.

Actinomycosis, *bony lesions* of *actinomycosis* and *mycetoma* are described on pages 171, 175.

Epiphysitis (Osteochondritis).—Varieties: (1) *Osteochondritis deformans juvenilis coxæ* (Legg's or Calvé-Perthes disease). (2) *Epiphysitis of the tibial tubercle* (Osgood-Schlatter disease). (3) *Epiphysitis of the tarsal scaphoid* (Köh-

ler's disease). (4) *Epiphysitis of the head of the second metatarsus* (also called Köhler's disease). (5) *Vertebral epiphysitis* (Schlatter's disease). (6) *Epiphysitis of the os calcis.* (7) *Epiphysitis of the olecranon.* (8) *Epiphysitis of the various epiphyses of the ilium.* (9) *Malacia of the semilunar bone.* (10) *Osteochondritis dissecans* (of König).

Epiphyses obtain their blood-supply from the periosteal network of arteries (large branches of which perforate the thin layer of compact tissue on the exterior, and are distributed throughout the spongy cancellous tissue), almost entirely independent of the diaphysis. Only one or two minute arteries pass into the epiphyses from the diaphysis through the conjugal cartilage.

In adult life the epiphyses may freely communicate with the diaphysis, but before fusion occurs they are shut off from the diaphysis by the epiphyseal cartilage.

Etiology of epiphysitis is: (1) *Infection;* (2) *endocrine disturbances;* (3) *trauma.*

Osteochondritis Deformans Juvenilis Coxæ (Coxa plana, Pseudocoxalgia, Legg's Disease [1910], **Calvé-Perthes Disease**).—A disease of adolescence, characterized by degeneration of the epiphysis of the head of the femur following trauma or other cause. It occurs chiefly in boys between the ages of ten and twenty, often after injury, with flattening and bulging of the femoral head, broadening of the femoral neck, followed later by fragmentation, necrosis, and epiphyseal separation. At times there are corresponding changes in the acetabulum, and effusion into the joint. The bone shows fragmentation, loss of normal trabeculation, followed by increased density from deposit of lime salts. The diaphysis is not affected. The cause may be a *staphylococcus.*

Symptoms.—Intermittent limp, with limited abduction and internal rotation.

Diagnosis from tuberculosis may be difficult. In tuberculosis the symptoms are more severe, and are associated with muscular spasm.

The *prognosis* is good under treatment.

Treatment.—Rest in bed, followed by plaster case, with the thigh in abduction and external rotation for eight to twelve months. A residual limitation in abduction and external rotation may remain.

Separation of tibial tubercle or **Osgood-Schlatter disease** (Osgood, 1903; Schlatter, 1908) occurs in boys between thirteen to fifteen years, while simple traumatic separation of the epiphysis is more common between sixteen and eighteen years of age. The roentgenogram shows the bony nucleus altered in shape, irregular, fragmented, with disappearance of the normal trabeculæ. The end-result is the normal restitution of the tubercle to its position and appearance (see page 321).

Köhler's disease of the navicular (**tarsal scaphoid**) occurs usually between the ages of three and ten, usually in boys, with slight clinical symptoms, such as pain and swelling in the region of the tarsal scaphoid. Roentgenograms show the bony nucleus of the scaphoid smaller, irregular in outline, and of increased density; similar to that seen in *osteochondritis deformans coxæ*, except that there is no fragmentation of the bony nucleus. The joint spaces remain clear, and the surrounding tarsal and metatarsal bones are normal.

Köhler's disease of the second metatarsal (**Freiberg-Köhler disease,** *infraction of the metatarsal head* [Freiberg, 1914; Köhler, 1924], *juvenile deforming metatarsophalangeal osteochondritis, metatarsal epiphysitis*) has seven cardinal signs: (1) Changes in the base of the proximal phalanges; (2) broadening of the joint spaces; (3) irregularity of the joint spaces; (4) flattening of the head; (5) calcium bodies in the joint capsule; (6) thickening of the distal half of the metatarsal bones, and (7) disappearance of the neck of the bone (see page 328).

TUMORS OF BONE

Nomenclature of Bone Tumors (After the Codman Registry)

I. *Osteogenic Tumors:*
  A. *Benign:*
    1. Exostosis.
    2. Osteoma.
    3. Chondroma.
    4. Fibroma.
  B. *Malignant (Osteogenic Sarcoma):*
    1. Gross anatomic types:
      a. Medullary and subperiosteal.
      b. Periosteal.
      c. Sclerosing.
      d. Telangiectatic.
    2. Undifferentiated sarcoma.
    3. Periosteal fibrosarcoma.
II. *Parosteal Sarcoma.*
III. *Giant-cell Tumor.*
IV. *Myeloma.*
V. *Ewing's Tumor* (probably *Endothelioma*).
VI. *Angioma:*
  A. Benign.
  B. Malignant (angiosarcoma).
VII. *Metastatic Tumors:*
  A. Carcinoma.
  B. Sarcoma.
  C. Hypernephroma.
VIII. *Osteitis Fibrosa Cystica.*
IX. *Inflammatory conditions* that may stimulate tumors:
  A. *Osteoperiostitis:*
    1. Traumatic (bone callus).
    2. Syphilitic.
    3. Infectious.
  B. *Myositis ossificans.*
X. *Odontoma.*

Exostoses are homologous outgrowths of bone, differing from hypertrophies in their asymmetry and limited involvement and from osteomas and true tumors in their development or origin from irritation.

Varieties.—(1) *Exostosis*—growing from the surface of bone. (2) *Enostosis*—growing into the medullary cavity (rare). (3) *Hyperostosis*—diffuse bony outgrowths. (4) *Osteophyte*—localized dendritic outgrowth.

Outgrowths of cancellous bone, covered by cartilage and at times a bursa, spring from the epiphyseal area of long bones.

Ossification of tendons or *muscle* occurs at their area of insertion in bone.

Subungual exostoses grow from the last phalanx under the nail, usually of the great toe.

Site.—Epiphyseal ends of long bones, the skull, and maxilla.

Pathology.—The outgrowths consist of cancellous or compact bone, cartilage, or fibrous tissue; encapsulated, and often covered by a bursa. The periosteum is expanded but not thickened, the soft tissues are pushed aside, but not involved. Exostoses are often multiple and symmetrical, pedunculated, or sessile. They arise subperiosteally—chiefly from long bones, near the epiphysis or origin of muscles and ligaments—and tend to grow in the direction of the diaphysis as the shaft elongates.

Etiology.—Exostoses may be hereditary or have a traumatic basis. They occur in the young and in the growing period, ceasing to grow at or before the twenty-fifth year.

Symptoms.—Hard, fixed, painless outgrowths of bone, tending to slowly enlarge during the growing period, producing deformity but little disability.

Roentgenogram shows subperiosteal production of bone, with expansion but no thickening of the periosteum.

Treatment is required only when the outgrowth produces objectionable deformity or disability. Surgical excision is carried out by burr, chisel, gouge, bone forceps, or saw.

Osteoma (Bone Tumor).—Varieties: (1) *Osteoma durum* or *eburneum*, compact or ivory osteoma. (2) *Osteoma spongiosum* or *medullare*, spongy or cancellous osteoma. (3) *Homologous osteoma.* (4) *Movable periosteal osteoma.* (5) *Parosteal osteoma*, situated near bone. (6) *Disconnected osteoma*, growing in tendons and muscles. (7) *Heterologous osteoma*, occurs in meninges, lung, diaphragm, parotid, and skin.

Homologous osteoma grows from the external and internal surfaces of the skull, especially from the frontal bones in the orbit or sinuses, the external auditory canal, the body of the jaw and angle of the mandible, and usually consists of dense ivory-like bone. It also springs from the scapula and pelvis.

Pathology.—Smooth, rounded, lobulated or irregular, sessile or, more rarely, pedunculated, well-encapsulated bony growths. On serous membranes, as the *falx cerebri*, they occur as flat plates.

Histology is that of hard or cancellous bone. The haversian systems are less regularly arranged than in normal bone. It is difficult to draw a sharp line of differentiation between an inflammatory exostosis and a true bone tumor or osteoma.

Symptoms.—The tumor, in itself painless and of slow growth, may produce marked deformity or distressing symptoms from pressure.

Treatment.—*Excision:* Against ivory osteoma growing from thin bony plates of the face or skull the mallet and chisel or bone forceps may produce dangerous fracture. Burrs rotated by an electric motor or small hand-saws are much safer. Osteomas not involving the face or skull are conveniently removed by the chisel or gouge.

Chondromas are semimalignant tumors, occasionally having a tendency to recur or give metastasis.

Seats.—Extremities of the long bones, especially the phalanges, the lower end of the femur about the popliteal space (where they may reach enormous size), about the hip-joint, the great trochanter, the upper end of the humerus, the neck of the scapula, and about the glenoid fossa.

Pathology.—The tumor may be peripheral or central. In the medulla the tumors are of slow growth, usually local, and cause a bulging of the periosteum, with little production, but usually absorption, of bone. Frequently there is a sarcomatous admixture. The growth consists of fibrous or hyaline cartilage, frequently becomes cystic and degenerates, with ulceration of overlying skin and with sinus formation.

Symptoms.—Chondromas are not painful except from nerve pressure. They form firm, bosselated, slightly elastic growths, which are firmly attached to bone.

Roentgenogram gives the appearance of a cystic, loculated tumor, with irregular trabeculations from bony and calcareous deposits. It is found in cancellous bone, and invades the epiphyses. Cartilage produces no shadow on the films.

Fig. 98.—Multiple enchondromas of the phalanges of the left hand.

Prognosis.—Skeletal chondromas are related clinically to osteogenic sarcoma and, while primarily benign tumors, are persistent, grow to large size, tend to recur after incomplete surgical removal, and finally may metastasize. The growth restraint is low or absent. Traumatism (including operation) may light up latent malignant tendencies, with recurrence and secondary growths in the lungs, liver, and spleen.

Treatment.—*Excision*, together with the adjacent bone. Often excision without mutilative destruction of the bone is not feasible. Amputation is advised if sarcomatous tendencies are evident.

Fibromas.—**Site:** Fibromas grow from periosteum or, less frequently, the medulla. They involve the maxillæ, the bones of skull, or vertebræ, pelvis, or long bones.

Pathology.—If of long standing, fatty, cystic, or calcareous degeneration is common. Ossification is rare. Often the tumor is mixed, a fibrosarcoma or fibrochondroma. Development is slow and often ceases at maturity, after which the tumor may atrophy and even disappear. The most common are the nasopharyngeal polyp of adolescence, and epulis. The former originates from the under surface of sphenoid, and fills the nasopharynx, pushes into the nasal fossæ and antrum on one or both sides, and may involve the sphenopalatine foramen, causing extensive displacement of the facial bones. It is dangerous from profuse, re-

current hemorrhage, and produces emaciation and asthenia from interference with breathing.

Treatment.—Extirpation, with removal of a shell of the attached bone. Nasopharyngeal polyps may spontaneously disappear after the age of twenty-five. If the symptoms are severe, extirpation or necrotizing injections (50 per cent. quinin-and-urea-hydrochlorid solution, or 96 per cent. alcohol) should be used.

Sarcomas of bones are usually primary. They are common in infancy and childhood and are rather rare after forty, except in Paget's disease of bones. There is a history of preceding injury in 50 per cent.

Fig. 99.—Osteosarcoma of the upper third of the humerus. (Roentgenogram by Dr. G. C. Bird.)

Varieties.—*Round-cell, spindle-cell,* or *mixed-cell sarcoma.* A moderate number of giant-cells may be present. Myxomatous tissue in a tumor of bone usually indicates malignancy. The degree of malignancy of the tumor is inversely as the maturity of cellular development (Broders' law).

Seat.—Maxillæ and long bones, especially the adjacent ends of femur and tibia. The joint is spared until late. The growth may pulsate, crepitate (*egg-shell* or *ping-pong crackling*), or cause fracture. The so-called "aneurysms of bone" are usually sarcomas. Hemorrhagic, fatty, cystic, calcareous, or osseous degenerations are frequent. Dissemination is by the blood stream, rarely through the lymphatics.

Symptoms.— Pain, swelling, increased heat, with little or no joint impairment or muscular spasm.

Diagnosis.—Osteosarcoma should be differentiated from rheumatism, tuberculosis, syphilis, osteitis fibrosa, bone cysts, giant-cell tumor.

Prognosis.—Usually unfavorable despite amputation or radiation treatment.

Treatment.—1. *Excision* or *amputation.*

2. *Coley's Mixed Toxin:* A ten-day-old agar-culture of *Bacillus prodigiosus* is sterilized by heat, and added to a three-week-old sterilized broth-culture of the *streptococcus* (approximate proportions: 100 c.c. of streptococcus culture, 30 c.c. of prodigiosus culture, and 30 c.c. of glycerin). The preparation is injected subcutaneously or intratumorally. If no improvement is obtained in four weeks, the treatment is discontinued. If there is improvement, the injections are given every one to four weeks for a year or more. Marked reaction, with high fever, violent chill, dyspnea, vomiting, and malaise, is common after the injection.

3. *Radiation* converts the cellular tumor into a quiescent bony mass; but may, if overused, cause rarefaction of the bone and predisposition to fracture, or pro-

duce radiation neuritis and extreme pain. *Metastases* may be held in check by radiation. Tumors with a preponderance of myxomatous tissue, skeletal chondromas, and sclerosing osteogenic sarcomas resist radiation.

Amputation rarely prevents metastasis or recurrence, even if done early. Both radiation and amputation or disarticulation are palliative measures, to be considered in prolonging life and relieving pain. Resection of bone, for the more malignant types of sarcoma, or exploration without immediate amputation, is unwarranted, as is the introduction of radium into the tumor.

Classification of Bone Sarcoma.—(1) *Parosteal fibrosarcoma.* (2) *Osteogenic sarcoma.* (3) *Ewing's sarcoma.* (4) *Myeloma.* (5) *Unclassified.*

Parosteal or **periosseous fibrosarcoma** is not a true bone tumor, but lies adjacent to bone and may, by local pressure, produce atrophy and bending without invasion of the bone. It is globular, firm, elastic, fairly encapsulated, and of rapid growth.

Histologically, it consists of spindle-cells, and is indistinguishable from fibrosarcoma of fascia. There is no osteogenesis or cartilage formation.

Symptoms.—A painless or painful, palpable, localized, encapsulated, slowly growing tumor; at first not invading but displacing the soft tissues, and producing absorption of bone by pressure without bone formation.

Prognosis should be guarded. Recovery occasionally follows complete excision, but recurrence is not infrequent, even after an interval of five to twenty years. Metastasis is much less common than from osteogenic sarcoma. Recurrence is often excited by trauma.

Treatment.—Free *excision*. *Radiation* is used for recurrences or for tumors that cannot be excised.

Osteogenic Sarcoma (Ewing).—A malignant tumor of bone or an *osteoblastoma*, having osteoblastic derivatives as its chief cells. The cells vary from spindle-cells to mucoid, cartilage, or true bone-cells. The cellular type and tendencies vary in different tumors, being (a) *sclerosing* or *osteoblastic*, with ossification of the intercellular substance, or (b) *osteolytic* with bone absorption and destruction. The osteoblastic type is more common in children, the osteolytic in adults. The latter type more frequently invades the epiphyses. The growth may originate from the medulla (*central sarcoma*), periosteum, or subperiosteal tissue (*periosteal sarcoma*).

Cytology.—Small hyperchromatic spindle-cells are the most common; large spindle-cells, polyhedral cells with multiple nuclei, and cartilage cells of osteoblastic type are found. The tumor never consists of round cells, nor are giant-cells found in large number. Lamellary bone formation, with parallel lamellæ containing typical bone-cells in lacunæ, is rare.

Trabeculated bone formation with non-lamellated, homogeneous, or fibrillated trabeculæ are common. An infiltration of lymphocytes is not unusual, and expresses a resistance of the body to the growth. Hemorrhages within the tumor often occur.

Incidence.—One sarcoma out of three is osteogenic. At one time one person in 100,000 had an osteogenic sarcoma. It is twice as frequent as the giant-cell tumor of bone.

Site.—Metaphyses of long bones. Seventy-two per cent. involve the lower

extremity, and 82 per cent. of these occur near the knee. In approximate order of frequency: The femur (52 per cent.), tibia (20 per cent.), humerus (9 per cent.), pelvis, fibula, bones of the shoulder-girdle, ulna, bones of the hands and feet (except the phalanges), ribs and skull, jaws, and vertebræ are involved. It is extremely rare in the lower end of the *radius* which is a common seat for giant-cell tumor. In the *femur*, in 82 per cent. the involvement occurs in the lower metaphysis; in 9 per cent. in the region of the great trochanter. It is rare in the head and neck of the femur. At the trochanter, the growth may have a pedicle, and show cartilaginous or cystic degeneration. In the *tibia*, 90 per cent. involve the upper, inner aspect. The *humerus* is affected chiefly in the upper third, the growth being rare below the deltoid tubercle. In the *pelvis*, the growth is found chiefly

Fig. 100.—Osteosarcoma of the upper end of the femur. (Roentgenogram by Dr. G. C. Bird.)

in the crest of the ilium, or in the ischium, seldom in the pubis or tuber ischii; in the *fibula*, in the upper, rarely in the lower end. Of the bones of the *shoulder-girdle*, the scapula is usually involved, especially about the glenoid fossa. The *ulna* is affected in its proximal end, no instance of distal involvement being recorded. Of bones of the *feet*, only the large ones are attacked. The *skull* is involved chiefly in children, the lower *jaw* more frequently than the upper. The *vertebræ* are rarely affected. There is no record of an osteogenic sarcoma of the patella. The fact that the lower epiphyseal end of the femur and upper epiphyseal end of the tibia are the last to ossify may explain the predilection for this area. The sarcoma may be engrafted upon a multiple chondro-exostosis,

as in Paget's disease, and the presence of osteogenic sarcoma in later life is almost presumptive evidence of Paget's disease. Fourteen per cent. of all patients with Paget's disease die of osteogenic sarcoma (Codman).

Etiology.—(1) *Male sex*, three to one. In the first decade the female sex predominates. (2) *Age*, chiefly the second decade. Osteogenic sarcomas occur at all ages, but are least frequent in the first decade; no congenital case has been reported. (3) *Trauma*—30 per cent. of the sarcomas develop within one month after an injury to the bone.

Symptoms.—1. *Pain* is due to the highly sensitive periosteum, is often very severe, boring, rheumatoid, gnawing, and aggravated at night. Usually there is a tired feeling, with uncertainty of muscular power, and a limp. In the early stages, intermittent, dull pain may immediately follow trauma, last one or two weeks, disappear (a limp remaining); the pain, of deep-seated and excruciating

Fig. 101.—Osteosarcoma of left ischium. (Roentgenogram of Dr. G. C. Bird.)

character, later reappearing, to be followed by local enlargement of the bone. Intermittent pain, however, is more typical of Ewing's sarcoma than of osteogenic sarcoma. Pain may quickly disappear after radiation. Tenderness is occasionally found. Pain is also present in osteomyelitis with pus between the cortex and periosteum, in syphilitic periostitis, and in sclerosing non-suppurating osteomyelitis.

2. *Tumor.*—The bone finally shows local swelling, the overlying skin is pale, stretched, with dilated veins, and is warmer than the surrounding skin. Ulceration is rare, but later edema, a purplish tint, excoriation, vascular pulsation, or a bruit may be present. *Eggshell crackling (ping-pong ball crackling)* is uncommon. Muscular spasm and interference with joint function, except mechanically or by late invasion, are absent.

3. *Constitutional symptoms* are absent, and the general nutrition is good,

until the later stages of the disease. The secondary anemia gives a chalky color instead of the lemon-yellow cachexia of cancer. Occasionally there is fever, which may be temporary or recurrent, and at times a hyperleukocytosis, with lymphocytosis and a 3 to 5 per cent. myelocytosis.

4. Exploratory incision or trauma may accelerate the growth. *Pathologic fracture*, which may occur from slight injury, is transverse or of the rotten-wood type. Union may occur, as after pathologic fractures from carcinoma. The articular cartilage resists invasion. The joint enlargement is usually fusiform, resembling a tuberculous arthritis.

5. *Dissemination of the tumor* through the blood or lymphatics usually occurs within two years, and may cause death within two months. Metastases to the lungs, abdominal organs, brain, bones, and skin are common; to the regional lymph-nodes rare. The secondary growths in the lungs are usually of low malignancy.

Fig. 102.—Osteosarcoma of lower end of femur with production of new bone and spontaneous fracture. (Roentgenogram by Dr. G. C. Bird.)

Diagnosis is made by clinical, roentgenologic, and pathologic study. One or all of these, however, may fail to establish the exact diagnosis. In the early stage a sarcoma differs from articular rheumatism in the free painless movement of the joint, the enlargement of the bone, and the pulsation of the tumor. True aneurysm of bone has not been proved. Myxomatous tissue in bone always suggests the presence of sarcoma.

Roentgenologic: (1) Indefinite outline. (2) Spindle shape. (3) Ossification at the ends of the growth under the raised periosteum, with a wedge-shaped, osteophytic thickening (*lipping of the periosteum*). (4) *Fan-like* or "sun-rays" appearance is found in 18 per cent. of osteogenic sarcomas. The radiating spicules and excessive bone production are more common in persons under twenty. Expansion of the true shaft is rare, although the tumor penetrates the bone and forms an enlargement about the shaft.

Prognosis is bad, irrespective of the treatment used. The duration of life is longer if the sarcoma develops after rather than before the age of thirty. Rapid growth and early metastases are common in children. The prognosis is especially unfavorable in osteogenic sarcoma near the trunk and gravest when the femoral neck is affected. Death almost invariably occurs within three years after radical excision of the clavicle for osteogenic sarcoma. Sarcomas of the

bones of the feet and hands, and the osteocartilaginous tumors of the jaw, are somewhat less malignant than similar tumors of long bones. Osteoblastic, osteogenic sarcoma or sclerosing sarcoma gives a rather better prognosis than osteolytic sarcoma. Large size without metastasis, and prolonged encapsulation are favorable. A lower malignancy is suggested by an adult type of cell, a slowly growing tumor, and leukocytic infiltration; high malignancy by small spindle-cells, pleomorphism, necrosis (not due to radiation), telangiectasia, or marked vascularity.

Recurrence is more common than metastasis, and usually takes place in the first two years after excision. To determine metastasis Roentgen-ray examination of the bones of the body should be made.

Treatment.—*High amputation* is rarely to be considered, except as an early and very radical procedure. An *amputatio interscapulothoracalis* has been used for involvement of the upper end of the humerus, and *amputatio interileoabdominalis* for involvement of the femur. Palliative treatment (including injection of the *mixed toxins of Coley*, Roentgen-ray or radium radiation, at times with local excision) is usually to be preferred to amputation, especially as recurrence within three years of amputation is usual.

The *mixed toxins of erysipelas* and *Bacillus prodigiosus* (Coley) are only useful in the spindle-cell types characterized by little production of new bone. The use of mixed toxins and *radium* have been followed by the disappearance and apparent cure of a number of cases of "round cell," but neither toxins nor radium, singly or combined, have effected a cure in any case associated with marked new bone production.

The value of *prophylactic radiation* of the lungs and other organs to prevent metastasis has not been proved, and may be harmful by reducing the general resistance of the patient.

Ewing's sarcoma—*endothelioma of bone* (Ewing, 1920)—consists of small polyhedral cells and is very malignant. It forms about 7 per cent. of the sarcomas of bone.

Site is usually the long bones, in order of frequency: tibia, fibula, humerus, ulna, and femur. It also involves the small bones of the feet, the ribs, vertebræ, mandible and skull, shoulder-girdle, and the pelvis. It is rare in the clavicle. It selects the shaft rather than the epiphyseal end of bones, involving a wide area—usually more than half the length of the bone, or the entire shaft. The epiphyseal end is not absolutely immune. In the spine, more than one vertebra is usually involved and, in the advanced stages, multiple lesions of the skeleton are usual.

Pathology.—The mass widely involves the shaft of the long bone or starts in multiple areas, spreading apart the lamellæ. The tumor is soft, mushy, whitish gray, and resembles granulation tissue; later forming a soft, crumbling, medullary growth that permeates the marrow and cortex with diffuse bone absorption. In the soft tissues there may be a thin pseudocapsule (with necrosis and liquefaction, suggesting pus or cyst formation) with yellow or red jelly-like contents. Although it is an invasive, bone-destroying tumor, bony trabeculæ may be formed from a creative regenerative process of the affected bone.

Cancellous bone is diffusely involved, the bony lamellæ are separated and

pushed apart by the tumor-cells; the tension and pressure lamellæ of the bones showing on the roentgenogram, the bone appearing thicker, as if edematous. The picture strongly suggests osteomyelitis; the cortical bone is destroyed by

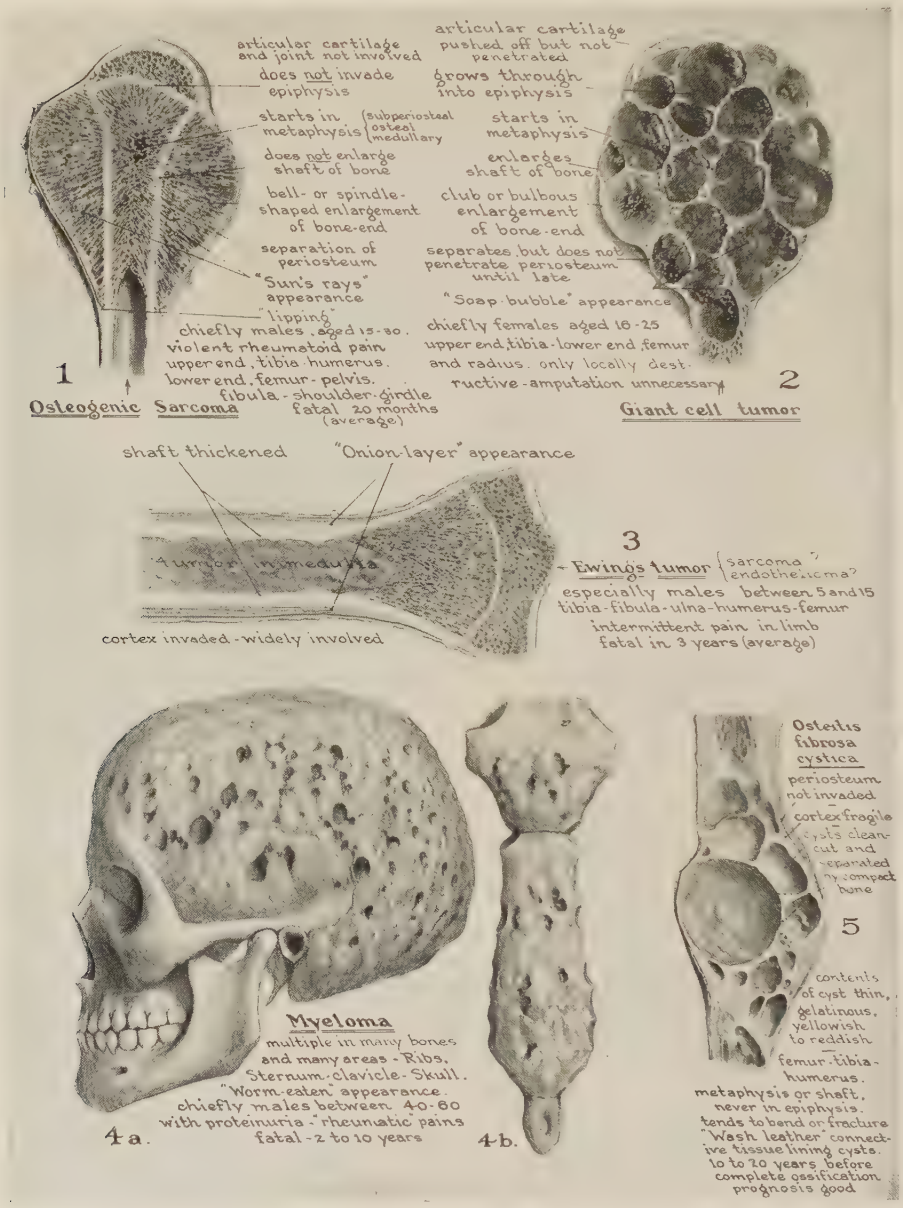

articular cartilage and joint not involved
does not invade epiphysis
starts in metaphysis (subperiosteal (osteal) (medullary)
does not enlarge shaft of bone
bell- or spindle-shaped enlargement of bone-end
separation of periosteum
"Sun's rays" appearance
"lipping"
chiefly males, aged 15-30.
violent rheumatoid pain
upper end, tibia, humerus.
lower end, femur, pelvis.
fibula, shoulder girdle
fatal 20 months (average)
1
Osteogenic Sarcoma
articular cartilage pushed off but not penetrated
grows through into epiphysis
starts in metaphysis
enlarges shaft of bone
club or bulbous enlargement of bone-end
separates, but does not penetrate periosteum until late
"Soap-bubble" appearance
chiefly females aged 16-25
upper end, tibia, lower end femur and radius, only locally destructive, amputation unnecessary
2
Giant cell tumor
shaft thickened
"Onion-layer" appearance
tumor in medulla
cortex invaded, widely involved
3
Ewing's tumor (sarcoma? endothelioma?)
especially males between 5 and 15
tibia-fibula-ulna-humerus-femur
intermittent pain in limb
fatal in 3 years (average)
Myeloma
multiple in many bones and many areas, Ribs, Sternum, clavicle, Skull.
"Worm-eaten" appearance.
chiefly males between 40-60
with proteinuria, rheumatic pains
fatal, 2 to 10 years
4a.
4b.
Osteitis fibrosa cystica
periosteum not invaded
cortex fragile
cysts clean-cut and separated by compact bone
5
contents of cyst thin, gelatinous, yellowish to reddish
femur, tibia, humerus.
metaphysis or shaft, never in epiphysis.
tends to bend or fracture
"Wash leather" connective tissue lining cysts.
10 to 20 years before complete ossification
prognosis good

Fig. 103.—Clinical differentiation of five important new growths in bone.

tumor-cells, which rarefy and diffusely dissolve the bone from within the haversian canals. A protective reaction of the periosteum leads to the formation of a shell of new bone, which later is penetrated and a new layer of bone laid down by the periosteum. Shell after shell of newly produced subperiosteal bone is thus per-

meated, producing newly formed *onion-like layers* parallel with the shaft, showing occasional foci of calcification, until finally the periosteum is penetrated and the soft tissues infiltrated.

Cytology.—The cell is small, uniform, rounded, or polyhedral, with round, oval, or slightly elongated nucleus. No giant-cells are present. Mucoid or hydropic degeneration of cells occurs, and frequently there is a perithelial arrangement about the blood-vessels. Intercellular substance is absent.

The *histology* may be complicated by a mixture with plasma-cells, blood-cells, and bone-marrow, or occasionally by lymphatic infiltration.

Metastasis.—Diffusion occurs by blood or lymphatics, especially to the lungs, and to the skull and other bones of the skeleton. Metastatic involvement of regional lymph-nodes is frequent, as is metastasis to other organs, especially the kidney, liver, and spleen. The regional lymph-nodes not infrequently enlarge with signs of local inflammation.

Etiology.—Fifty per cent. develop before the age of fifteen. Usually it occurs between the ages of five and fifteen years. Ewing's tumor is rare after forty, and frequently follows trauma.

Symptoms.—*Clinical Picture:* A young person after a seemingly trivial injury develops insidious fever, slight leukocytosis, limp, aching, and tumefaction of a bone. The diagnosis of osteomyelitis is usually made. The incipient attack subsides, to recur after several days or months.

The *pain*, which is more intermittent than that from osteogenic sarcoma, finally becomes continuous and of a rheumatoid character, by which time a thickening of the bone usually can be felt. There is a leukocytosis of 12,000 to 15,000, with a normal relationship in the differential count. Late in the course of the disease a marked secondary anemia appears. The skin usually remains free from involvement unless exploratory incision is made, when a large fungous growth forms. The tumor may become reduced in size or disappear, to return with a subsequent attack.

Pathologic fracture is not typical except in the terminal stage. Involvement of a joint or articular cartilage is unknown.

Roentgenogram shows characteristic longitudinal, subperiosteal striations ("onion layers"), usually involving more than half of the shaft, with thickening and widening of the entire shaft and cortex. There is little tendency to produce new bone, or the osteoid lines radiating at right angles to the shaft, seen in osteogenic sarcoma.

Prognosis is bad. Temporary improvement and retrogression is frequent under radiation. The separate layers of tumor tissue, laid parallel with the shaft of the bone, often disappear entirely after a few weeks' radiation, but tend to recur within a few months. Recurrent growths usually develop in the lungs, skull, or other parts, and prove fatal in from six months to two years.

Treatment.—Ewing's sarcoma should be treated by toxins, radiation, and, if there is no improvement in four to six weeks, by amputation.

Myelomas are central, very malignant tumors of bone, arising from the myelocytes of the bone-marrow.

Site.—The short bones, sternum, ribs, vertebræ, skull, clavicle, and the mid-portion of long bones.

Pathology.—Myelomas are multiple central tumors of bone. They consist of a solitary mass, destroying and absorbing the cortex in all directions; or hundreds of tumors may be present in the skull, ribs, and other bones. The growth invades the cortex, periosteum, and epiphysis of bone, is not bone producing, and consists of round cells resembling myelocytes.

Etiology.—*Age* usually between forty and sixty years.

Symptoms.—Mild rheumatic-like pains, weakness, loss of weight, secondary anemia. The contour of the affected bones may be normal or show palpable masses. Secondary deformity and fracture occur. *Bence-Jones proteinuria* is found in 80 per cent. of the cases.

Roentgenograms show multiple clear-cut areas of bone absorption (*moth-eaten appearance*), beginning in the medulla and involving all portions of the bone.

Diagnosis.—The age, central character, multiplicity of lesions, and clear-cut defect (without bone production, but with proteinuria) differentiate myeloma from other tumors of bone.

Prognosis.—Fatal in two to five years despite treatment. Temporary improvement with prolongation of life may follow radiation.

Treatment.—*Radiation* and *mixed toxins*. Excision or amputation is of no avail.

Benign Giant-cell Tumor (Bloodgood).—Formerly called *myeloma, myeloid tumor, giant-celled sarcoma.* A soft, reddish, currant-jelly-like, brownish-red or chocolate-colored, vascular central tumor of the ends of the long bones; characterized by many large giant-cells resembling those normally present in marrow. The growth recurs if incompletely excised or destroyed, but does not metastasize.

Site.—Metaphyses, especially the upper end of the tibia, the lower end of the femur, and the lower end of the radius. The humerus is rarely involved. The overlying bone becomes thin and expanded, finally is perforated, and the growth often extends to the articular cartilage.

Pathology.—A vascular, central, giant-celled tumor, which spreads from the metaphysis through the epiphysis, being limited by the articular cartilage and periosteum. There is no production of bone, the osteolysis destroying the bony cortex with impaction and fracture. Telangiectasia, hemorrhage, and cyst formation are common.

Etiology.—Giant-cell tumors usually occur between the ages of twenty-five and thirty-five, and frequently follow injury. They are rare in childhood and old age.

Symptoms.—Mild pain with progressive bulbous enlargement of the end of a long bone, especially near the knee- or wrist-joint. The symptoms may continue for years without affecting the general health. The growths pulsate or have a bruit, and the thin overlying bone may show eggshell crackling. The joint function usually is unimpaired, the skin is hot and may show venous engorgement. Secondary disability follows fracture or impaction of the weakened bone.

Roentgenogram.—An expansive growth with "soap-bubble" appearance, absorption of bone, and destruction of epiphysis (largely unilateral), the margins not being as clear cut as in *osteitis fibrosa cystica.*

Diagnosis.—A central tumor of the metaphyses of long bones—thinning and expanding the cortex, extending to the articular cartilage, not affecting the function of the adjacent joints, without evidence of inflammation, and showing an area of bone expansion and absorption on the roentgenogram—is characteristic. The tumor rarely involves the head or neck of the femur, which frequently is involved by tuberculosis and other inflammatory conditions. The joint is usually free from effusion or ankylosis.

Prognosis.—As emphasized by Bloodgood, giant-cell tumors of bones do not recur after local excision or destruction, and do not metastasize.

Treatment.—Early thorough curettage, and the application of zinc chlorid (10 per cent. solution) to the cavity to destroy residual cells. In the upper extremity amputation is never required. In the lower extremity amputation may give a better functional result for an advanced tumor, the excision of which will leave a large defect and loss of joint function. Radium should not be used in the bone cavity on account of troublesome secondary infection and necrosis.

Aneurysm of bone (*pulsating hematoma*) usually consists of a very vascular sarcoma or giant-cell tumor. It is found most frequently in the lower end of the femur, the upper end of the tibia, and in the bones of the pelvis. The pulsation and bruit may disappear on compression of the main artery. There may be eggshell crackling. *A pure aneurysm of bone is questioned*, while an angiosarcoma is relatively common.

Differential Diagnosis of Bone Tumors.—*Primary malignancy in bone* usually occurs in youth or early adult life, and often causes pathologic fracture. It has the following misleading symptoms:

(1) History of preceding injury in 50 per cent. (2) General appearance of robust health at time of onset. (3) Acute onset with pain, worse at night, often associated with increased local and general temperature and leukocytosis, suggesting inflammatory disease. (4) Biopsy and microscopic evidence that may simulate inflammatory disease. (5) Roentgenogram which may simulate inflammatory disease. (6) Rapid but transient improvement from Roentgen-ray treatment.

The following symptoms belong to inflammatory disease (tuberculosis, syphilis) and not to malignancy of bone: (1) Preceding impaired health or cachexia. (2) Early epiphyseal and joint involvement. (3) Muscular spasm and rigidity. (4) Early multiplicity of lesions. (5) Early edema, fixation, or inflammation of overlying skin. There is no such disease of the bone as rheumatism, neuralgia, or sciatica, yet these terms are commonly applied to serious osteogenic disease.

Osteogenic sarcoma usually grows from the metaphysis, chiefly the lower end of the femur, upper end of the tibia, upper end of the humerus, pelvis, fibula, or shoulder-girdle. It is more frequent in males between fifteen and thirty years. Acute, violent, gnawing, boring, rheumatoid pain, worse at night, followed by fusiform enlargement of one end of the bone, with bone absorption and bone formation, is present. The radiating spicules or plates of bone ("sun-rays appearance" on the roentgenogram) are fairly characteristic of advanced growth. The average duration of life is twenty months, and the very early metastases permit no delay in diagnosis if effective treatment is to be used.

Ewing's endothelioma or *sarcoma* affects a considerable area of the shaft of long bones, such as the tibia, fibula, humerus, ulna, femur, especially in males between five and fifteen years. There is widening of the shaft and a deposit of subperiosteal layers, forming longitudinal striations ("onion-layer appearance" on the roentgenogram). The patient has recurrent attacks of intermittent pain, a limp, and fever, with diffuse enlargement of the shaft of the bone easily mistaken for osteomyelitis. The average duration of life is three years.

Myeloma early becomes multiple, affecting many bones and many areas of the same bone, especially the ribs, sternum, clavicle, and skull. It occurs chiefly in males between forty and sixty years, with many areas of bone absorption, rheumatoid pains, and Bence-Jones proteinuria. It is fatal in two to ten years.

Giant-cell tumor involves the metaphysis and epiphysis, especially the lower end of the femur, the upper end of the tibia, and lower end of the radius. It is more frequent in females, and, between the ages of sixteen and twenty-five, is associated with moderate pain and globular enlargement of the bone end, distending the periosteum and pressing upon but not perforating the articular cartilage. Roentgenologically the "soap-bubble appearance" is suggestive. While locally destructive and deforming, it is not malignant, does not metastasize, and does not recur when destroyed. It does not necessitate amputation, but requires very early diagnosis and treatment to save a useful limb.

Secondary Malignant Tumors of Bone.—1. **Secondary carcinoma of bone** is common from a primary growth of the mammary gland, stomach, or prostate. The bodies of the vertebræ, the upper end of the femur and tibia, the clavicle, and the ribs are most frequently involved. Secondary growths of the skull occur from carcinoma of the thyroid. Often no symptoms are noticed until a pathologic fracture occurs or, with the spine, pressure upon the roots or cord is produced. With reduction and retention of the fracture, pain is relieved, and the bone may unite.

2. **Secondary sarcoma of bone,** while a frequent result from osteogenic sarcoma, Ewing's sarcoma, or myeloma of bone, rather rarely occurs from primary sarcoma of the viscera. Spontaneous fractures occur, and union after fracture is possible, but rare.

3. **Hypernephroma.**—With this very malignant tumor metastasis occurs through the blood-vessels, to the bones as well as to the lungs, liver, and lymph-glands. The bones chiefly involved are the femur, vertebræ, ribs, skull, clavicle, humerus, pelvis, scapula, jaw, tibia, and metacarpals. The average duration of life with hypernephroma is two and a half years.

Treatment of secondary malignancy of bone is palliative. Support and fixation should be used for fractures; opiates, chordotomy, or rhizotomy for the pain from a compression radiculitis.

CHAPTER XV

FRACTURES

A *fracture* is a break or an "interruption of continuity" in bone or cartilage, either partial or complete.

Varieties.—*A.* According to Degree: 1. *Complete fractures*, in which the bone is divided in two or more parts.

2. *Incomplete fractures*, in which the bone is not entirely divided. Incomplete fractures include: (a) *Greenstick fractures*, involving usually the radius, ulna or clavicle (in persons under fifteen years of age), and ribs—the bone bends

Fig. 104.—Types of deformity in fracture: Overriding, angular, and lateral.

on the concave side, and gives way on the convex side. (b) *Fissured, linear,* and *stellate fractures* in which there is splitting or cracking, usually involving the flat bones of the skull, but rarely the bones of the extremities, except as a part of a complete or comminuted fracture. (c) *Depressed*, "*pond*" or "*gutter*" *fractures* chiefly involve the bones of the skull. (d) *Splinter fractures* or *apophyseal fractures* are those in which a small linear fragment or bony prominence is torn from the bone.

B. According to Line of Fracture: 1. *Transverse fractures* closely follow the transverse axis of the bone. They usually occur in the lower end of the radius, in the femur, or the short bones.

2. *Longitudinal fractures* follow the bony axis or produce a split of a long bone; they are rare.

3. *Oblique fractures* are oblique to the axis of the bone.

4. *Spiral* or *torsion fractures* partially encircle the bone.

5. *Comminuted Fractures.*—The bone is broken in three or more fragments, due to the crossing of two or more lines of fracture. They may be: (a) V shaped, (b) T shaped, or (c) Y shaped.

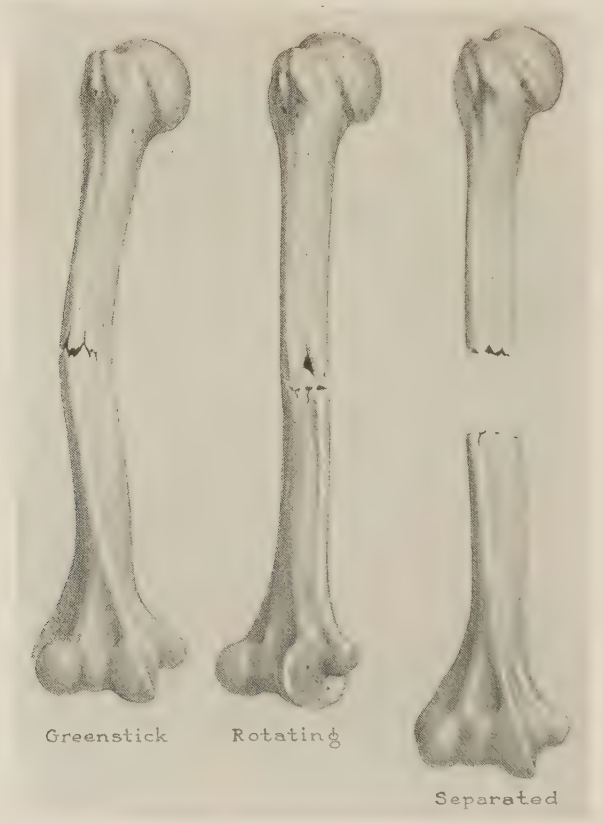


Fig. 105.—Types of deformity in fracture: Greenstick, rotating, and separated.

6. *Impacted Fractures.*—One fragment is driven into the other, producing fixation.

7. *Compression* or *crushing fractures* usually occur in the tarsal bones or bodies of the vertebræ.

8. *Complicated fractures* are associated with injury of an important adjacent structure—such as an artery, nerve, vein, joint, or viscus—or extensive comminution or extensive destruction of soft tissues.

9. *Subperiosteal Fractures.*—Rarely, a fracture may occur without tearing of the periosteum and with little primary displacement. These fractures may be difficult to recognize without Roentgen-ray study.

C. According to Location: Fractures are classified according to their location in a bone, as fractures of the shaft, neck, condyle, tuberosity, process, or an epiphyseal separation.

Epiphyseal separation is common up to the age of twenty, and in certain bones may occur to the age of twenty-five. The separation is favored by pyogenic, syphilitic, or tuberculous involvement of the epiphysis. The fracture runs through the diaphyseal side of the ossifying cartilage, and is usually associated with a laceration or stripping-off of the periosteum. The most common locations are the upper and lower ends of the humerus, lower end of the radius, lower end of the femur, upper end of the femur, and upper end of the tibia. Recovery without deformity occurs, but secondary progressive deformity from interference with the growth of the bone is to be feared. If infected, the epiphysis may be destroyed and the joint invaded, with secondary arrest of growth, and ankylosis or more serious infection, necessitating excision of the joint, or even amputation to save the patient's life.

D. Articular Fractures: Those invading or having an essential relation to joints:

1. *Intra-articular fractures* are those lying entirely within the joint.

2. *Periarticular fractures* are those extending close to, but not into the joint. The terms *intra-* and *extra-capsular* are also used, especially in relation to fractures involving the neck of the femur.

E. According to Application of Force: 1. *Direct*, occurring at the point struck.

2. *Indirect*, occurring at a point distant from that where the force has been applied. Subdivided into: *Bending*, *torsion*, *compression*, *avulsion*, and *bursting fractures.*

3. *By muscular action.*

F. According to the Absence or Existence of Exterior Communication: (a) *Simple Fracture (Closed Fracture)*: There is no open wound in the skin.

(b) *Compound Fracture (Open Fracture)*: An open wound in the skin or mucous membrane communicates directly or indirectly with the line of fracture.

G. Spontaneous or Pathologic Fractures.—These fractures may be classified according to cause, as follows:

1. *Agenetic*, as in osteoporosis, a congenital familial type of imperfect osteogenesis with an inherited tendency to fracture.

2. *Atrophic.*—(a) *Senile:* In old age, central rarefaction with absorption of the trabeculæ occurs, the absorbed bone being replaced by fat. The condition appears prematurely in certain persons. Fracture from this cause most frequently involves the neck of the femur. (b) *Dyscrasic:* The atrophy of bone occurs from prolonged debilitating disease, such as typhoid fever or scurvy, or special disease, such as osteomalacia. (c) *Disuse:* Prolonged immobilization or lack of use is followed by atrophy and weakening of the bone. (d) *Neurogenic:* In tabes, syringomyelia, paresis, and spina bifida, and after division of the

peripheral nerves, atrophy of bone favoring fracture occurs. (e) *Pressure:* An adjacent aneurysm, tumor, or other mass continuously pressing upon a bone may lead to its absorption and final fracture.

3. *Inflammatory.*—From osteitis, osteomyelitis, syphilis, tuberculosis, and infections of bone.

4. *Neoplastic.*—From bone tumors and cysts, especially carcinoma, sarcoma, giant-cell tumor.

Location.—In order of frequency, the various bones are fractured as follows: Radius, humerus, ribs, femur, clavicle, fibula, metacarpus, tibia, skull, tarsus, phalanges, inferior maxilla, and patella; the hyoid, coccyx, and sternum are bones infrequently broken. Approximately 45 per cent. of the fractures involve the upper extremity; 35 per cent., the lower; 10 per cent., the trunk; and 5 per cent., the head (Scannell). The curved shafts and spongy ends of the long bones of the extremities serve to absorb violence and protect the body proper, but may give way in doing so.

Etiology of Fractures.—1. **Age:** Fractures are most common about the age of thirty. In childhood, bones are elastic; in old age, activity is restricted. *Intra-uterine* and *congenital fractures* occur from external violence during pregnancy or, more often, from traumatism received during birth, especially from the manipulations of the obstetrician.

2. **Sex:** Fractures in *middle life* are ten times as frequent in men as in women and, *in general*, fractures occur three times as frequently in men as in women, due to the greater vocational dangers. In infancy and between the ages of fifty and seventy the incidence of fractures in the sexes is about the same, but after seventy the incidence is greater in women.

3. **Season:** Fractures are more common in the warm months because of the greater exposure due to active outdoor work and sports. Fewer fractures occur in the winter season, although the incidence of fractures of the leg (from falls upon the ice) shows a proportionate increase.

4. **Occupation:** Hazardous pursuits and games predisposing those engaged to falls, blows, and the like—as with riggers, football players, heavy construction workers—favor the production of fractures.

5. **Pathologic Changes Predisposing to Fracture:** (a) *Fragilitas ossium* occurs in children, and disappears in adult life. Repeated or multiple fractures occur without impairment of reparative function, so that the fragments usually promptly unite.

(b) *Osteomalacia* occurs in women in association with pregnancy, the bones tending to soften and bend rather than to fracture. There is marked deficiency in the mineral constituents of the bones.

(c) *Rickets* is associated with the softening of bones, due to deficient mineral matter. The long bones, particularly the tibia, femur, and ribs, become bent and distorted. In scurvy-rickets, the epiphyses or the epiphyseal junctions are chiefly affected.

(d) *Inflammations of the Bone:* In pyogenic osteitis and osteomyelitis, during the period of separation of the sequestrum, there is marked weakening of the bone, favoring fracture. Central abscesses of bone, tuberculous caries, and the gummatous lesions of syphilis in the bone favor fracture. Fracture from syphilitic

disease is much less common than from tuberculosis, and rarely involves the diaphysis.

(e) *Tumors of the Bone:* Sarcomas causing fracture are usually primary and begin in the medulla. Reunion rarely occurs. Carcinoma of the bone is usually secondary, the primary growth usually being in the mammary gland, uterus, prostate, stomach, or other organ. The bodies of the vertebræ, the upper and lower ends of the femur, the upper end of the tibia, and the clavicle are most frequently involved. If immobilized, the fragments will at times unite.

(f) *Myelomas and Neoplastic Bone-cysts:* Fracture is often the first evidence of cystic disease of bone, union not being prevented. Hydatid or echinococcus cysts of bone in rare cases lead to fracture. The diagnosis is made by Roentgen-ray examination, eosinophilia, the complement-fixation test, or by surgical exploration.

6. **Gunshot wounds of bone** cause bending, perforating, comminuting forms of fracture. The injury produced depends on the size and velocity of the missile, and on the area struck.

Repair of Fractures.—A fracture is followed by the formation of a blood-clot between and around the fractured ends, which soon is invaded by leukocytes and gradually replaced by fibroblasts and osteoblasts. On the second day there is a proliferation of the cells of the periosteum and bone-marrow, and two days later the osteoplastic layer of the periosteum has been transformed into a vascular germinal tissue, consisting of large polymorphous cells in a homogeneous or fibrillated matrix. Gradually the germinal tissue becomes differentiated, patches of osteoid and occasionally chondroid tissue appear, unite into trabeculæ, and later are transformed into bone. At the end of the second week the ends of the fragments are covered by a multitude of young osteophytes and osteoid trabeculæ which show the greatest proliferation close to the fracture about (1) the periosteum (*periosteal callus* or *ring callus*), and (2) the endosteum (*myelogenous, central*, or *pin callus*). By the end of the second or the third week the gap is bridged by trabeculæ, and between the bones (3) the *intermediary, definitive callus* is formed.

Callus formation is greatest about the diaphysis of long bones, less in the epiphyseal ends of small bones, in small cancellous bones, and in flat bones (such as the scapula), and is almost absent with the bones of the skull. In the skull no callus appears above the surface. In intra-articular fractures the extracapsular callus is large, the intracapsular scant. A joint may be bridged by osteophytes, causing bony anklyosis. In incomplete fractures the callus formation is much more limited. Absolute immobilization, slight separation, small amount of blood-clot, and slight laceration of the periosteum are associated with slight callus formation. In complete and comminuted fractures the extensive tearing of periosteum, the splintering, and periosteal displacement favor excessive callus formation. Widely separated splinters may not reunite, but may become rarefied and absorbed, thickened, or necrosed, and cause inflammation. Associated with the new bone production there is an active and progressive absorption of unnecessary bone by the osteoclasts. This progresses for months, contouring the rough edges, reducing the amount of extra callus, and, at times, reopening and restoring the medullary cavity.

Ossification occurs in from ten days (for the small bones of the face) to eight weeks (for the femur).

Regeneration of bone occurs chiefly from the inner layer of periosteum and the adjacent cortex. The outer layer of the periosteum forms a limiting membrane and is not osteogenic. Regeneration from aperiosteal bone and from endosteum is more limited. Hard bone placed in spongy epiphyses is absorbed, and replaced by spongy bone (Henderson). Firm bony union may be obtained without periosteum, but is less certain.

Bone with associated articular cartilage and periosteum is transplantable (Gill), and mild infection is not necessarily fatal to the graft. Free bone transplants with or without periosteum, placed in muscle or subcutaneous tissue or omentum, are usually ultimately absorbed. Contact with living bone usually determines the life of the transplant (Murphy). Osteogenic cells come from the periosteum, the endosteum, and the lining of the haversian canals. Lane's plates and screws inhibit osteogenesis, and are not desirable for union of bone. Cartilage cells may become osteoblasts (Macewen). Cartilage is potentially parent bone, and may be reformed from bone.

Symptoms of Fractures.—1. **Deformity** may be due to contusion or laceration of the soft parts, and to displacement of the bone ends upon each other. Most displacements can be detected by the eye or finger, but occasionally mensuration must be resorted to. Measurements are best taken from bony points at opposite ends of the bone whose fracture is suspected, and the shortening or lengthening determined by comparison with corresponding measurements of the sound limb. It is essential that such measurements be taken with the limbs in actually, not merely apparently, corresponding positions. It must also be borne in mind that limbs are often asymmetrical; or that previous disease may have altered the measurements. Circumferential measurement is valueless, because an increase is often due to effusion of blood into the soft parts rather than to overlapping of the bone ends. Generally the swelling of soft parts increases for twenty-four to forty-eight hours, and then gradually subsides, particularly under treatment. This is to be remembered in applying splints.

2. **Abnormal mobility** and **crepitus** are pathognomonic of fracture. In exposed positions the former sign is obtained by directly grasping the segments of the bone, and moving one upon the other; in other positions one must be satisfied with determining that the motions of one fragment are not imparted to the other, as indicated by the immobility of one of its bony points (as a tuberosity). Abnormal mobility near a joint must be differentiated from normal or abnormal mobility of the joint itself.

3. **Crepitus** is the grating heard or felt when two rough bone ends rub against each other. It is, of course, prevented by the intervention of soft parts, and may be simulated by crackling of coagulated blood, roughened joint surfaces, tenosynovitis, and emphysema. When a diagnosis can be made without attempts to elicit crepitus, it should not be sought, as manipulations cause pain and possible laceration of tissue.

4. **Loss of function** is usually present owing to weakness, pain, or loss of mechanical support. This symptom is misleading. One patient may walk with a fractured leg, and another be greatly disabled by a mere contusion.

5. **Pain** is always present unless the patient is unconscious. It is produced by: (a) *Direct digital pressure* over the line of suspected fracture, indicating fairly definitely the location and line of the fracture. (b) *Indirect pressure*, as by crowding the two fractured ends together by pressure against the distal portion of the injured part. In the latter instance the patient will localize the point of greatest pain at the site of fracture. Again, voluntary motion of the injured part against resistance will cause the patient to localize the point of maximum pain in the region of the fracture. Such definitely localized pain in a bone is usually due to fracture.

6. **Auscultation and Percussion.**—The percussion note over a fractured bone is changed by the interruption of vibrations. The interruption of sound-waves also may be noted by applying a vibrating tuning-fork above the supposed seat of fracture, while listening through a stethoscope placed on the bone below.

7. **Local swelling,** at first, is due to hemorrhage into the tissues from torn blood-vessels. Later the swelling is increased by inflammation, inflammatory exudate, and the impaired drainage of blood and lymph through torn or obstructed veins and lymphatics. The secondary swelling, especially when confined by a bandage or plaster dressing, may interrupt the circulation and cause gangrene.

8. **General reaction** is shown by slight fever with an increase in temperature of one or two degrees. A moderate polymorphonuclear leukocytosis occurs, which reaches a maximum in twenty-four hours and falls by the fifth or sixth day after proper reduction and immobilization. The reaction is less marked in old and debilitated persons than in children and younger adults, and expresses the degree of injury to bone, periosteum, and soft tissues (Walton).

9. **Secondary Suggillation and Hemorrhagic Blebs.**—After several days blebs appear on the surface over the fracture, and the tense skin becomes discolored from ecchymoses as the blood, extravasated among the deeper tissues, makes its way to the surface; this is a presumptive sign that a fracture exists. A black-and-blue discoloration back of the mastoid, appearing after three days (Battle's sign), is indicative of fracture involving the mastoid. In from four to five days the edema subsides, and the swelling is gradually reduced to a hard lump at the point of fracture. The mobility at the fracture becomes less; crepitus is no longer obtainable, as the fractured bone ends become covered with granulations. Finally, after two or more weeks, abnormal mobility disappears, and the fracture is said to be united. But, unless massage and passive movements have been used, disuse and exudate have stiffened the joints and weakened and fused the muscles, so that weeks or months are required before the limb regains its normal usefulness. Permanent stiffness may follow neglect of the proper care of adjacent joints and muscles.

Diagnosis of Fractures.—This should be made with the least possible manipulation. Careful inspection, gentle palpation, and accurate mensuration considered with the patient's history will usually suffice. If not, *gentle* manipulation of the injured part may be made for the purpose of eliciting abnormal mobility or crepitus. Anesthesia may be necessary to relax muscular spasm and relieve pain; the part must be carefully supported and protected so that

further laceration does not occur during the period of excitation from the anesthetic.

Roentgen-ray Examination.—In most cases a roentgenogram is not essential to diagnosis, but in fractures without displacement of fragments, in those in which classical clinical signs cannot be obtained, and in fractures of bones which cannot readily be palpated it is of great aid. It is invaluable in determining the result of any given method of reduction and retention. For their medicolegal value roentgenograms should always be made. Films should be made both before and after the reduction of fractures, and after the application of cases and splints. They safeguard the patient, give a basis for testimony, and frequently thwart a suit for malpractice.

Differential Diagnosis.—In *dislocation*, there is restricted motion where there was free motion before; in *fracture*, there is motion where there was none before; in one *preternatural immobility*, in the other *preternatural mobility*. If, in a dislocation, the range of motion is increased in one direction, it usually is diminished in the opposite direction; whereas a fracture usually causes abnormal mobility in all directions. Crepitus, pathognomonic of fracture, also serves to differentiate. In dislocation, the head of the bone is in an abnormal position; in fracture, it is in its normal position.

In case of *contusion* (except of the hip), position, rest, and pressure for a few days should reduce the swelling of the soft parts sufficiently to permit a satisfactory examination. If roentgenoscopy fails to clear the diagnosis, the only safe treatment is that for fracture.

Prognosis of fractures depends on the site and extent of injury, the associated lesions, the age and general condition of the patient.

Anatomical and Functional Result.—If, after union of a fracture, the *anatomical result* is good, the *functional result* will be good in over 90 per cent.; if the anatomical result is only fair, the functional result will be good in only 70 per cent.; if the anatomical result is bad, the functional result will be good in about 47 per cent. (Fracture Committee of the British Medical Association).

Secondary deformity results from: 1. *Displacement in length*, with (a) *impaction*, (b) *overlapping*, or (c) *distraction* (fractured olecranon or patella).

2. *Lateral Displacement:* (a) *Partial*, with the fractured ends still in contact; (b) *complete*, and (c) *with* or *without overlapping*.

3. *Angulation* of the long axis of the bone.

4. *Rotation*.

Shortening has little affect on muscular function. Lateral displacement and overlapping need not seriously impair function if the axes of the bone and joints have been maintained. Angulation and rotation seriously impair function by altering the line of pull of muscles and the axes of joints. The nearer the fracture is to a joint, the greater the disability. Rotation limits supination of the hands, and causes inversion or eversion of the foot. Angulation in proximity to a joint with wide separation of fragments is especially serious.

Complications of Fractures.—Among the accidents that may imperil the patient's life are: *Embolism*—either a *clot* from an injured vein, arrested in the heart or lung, causing death, or *fat embolism*, a rare condition which occurs during the first few days after fracture, and likewise is usually fatal. *Shock*, *hemor-*

rhage, *tetanus*, *septicemia*, or *pyemia* may influence the prognosis unfavorably. *Delirium tremens* is a frequent and serious complication in alcoholic habitués. The shock, the withdrawal of customary alcoholic stimulation, and the confinement to bed all tend to induce it. Such patients should have the fracture immobilized and be taken out of bed in order to abate the attack. From laceration of the main vessels of a limb or from their compression, whether by the displaced fragments, blood, exudate or by a case, splint, or bandage, release from pressure or constriction unskilfully applied, *Volkmann's contraction*, local *sloughing* of the tissues, or *gangrene* may occur. In such cases, reduction of the fracture, warmth, support, mild antiseptic fomentations, and the elevation of the limb constitute the elements of prophylaxis. Occasionally, early incisions for the evacuation of clots, or the ligature of bleeding points are necessary to save the limb.

Other early complications are the secondary compounding of the fracture by a sharp point of bone, and the formation of a traumatic aneurysm from a lacerated artery.

Complete return of function may be delayed or prevented by exuberant, painful, or weak callus. The callus is often exuberant at first, but later is absorbed. Masses of callus, that impair function and are not absorbed, should be exposed and chiseled away. With an old fracture, it may be impossible to tell before operation whether the offending mass is a badly reduced fragment, or exuberant callus. Persistent pain in the callus is often due to pressure on a nerve, or the inclusion of nerve-filaments in the callus, or to inflammation or suppuration about a sequestrum. Progressive increase in size of callus (with pain) suggests *sarcoma*, which may have been incited by the traumatism. Weakness of the callus may be due to undue separation of the fragments, constitutional debility, disease, inefficient immobilization, or, in compound fracture, to suppuration.

The stiffness of joints which results from immobilization treatment should be transitory, except in the old, gouty, and rheumatic, in whom it may persist. However, if the joints have been sprained or involved in the fracture, exuberant callus or bony union of the apposed bone surfaces may interfere with the movement of the joint. The joints of the fingers often remain stiff, and require much after-treatment if they are immobilized in extension for more than two weeks.

Treatment of Fractures.—1. **Prevention of further injury,** by immediately splinting the injured part before the patient is moved or transported, is most important. For fractures of the clavicle, scapula, shoulder, arm, or elbow, the extremity is fixed to the side of the chest by a Velpeau bandage. For the forearm and hand, anterior and posterior padded board splints may be used, with a suitable sling for the arm. For the thigh or leg, an external board-splint (Liston's long splint) from the axilla to below the heel (with pillow and side splints, bandaged or tied together) is useful. The Liston splint is supported by a broad band about the body, and the apparatus bandaged to the opposite leg. The Thomas splint is excellent for fractures of the thigh or leg, giving support with extension in transportation. For fractures of the pelvis or spine, the body should be immobilized by being firmly fastened to a Bradford frame, a firm

cot or litter, or by fixing the body and legs by broad swaths between two well-padded, long Liston splints.

2. **Reduction of the fracture** (*"setting" the broken bone*) should be accomplished as soon as possible after the diagnosis of the fracture, and of any associated lesion, has been made. Examination should be made for dislocation, injury of important nerves, blood-vessels, muscles or tendons before attempting reduction, otherwise the associated injury may be later ascribed to the treatment used. While Roentgen-ray examination is desirable, reduction should not be delayed awaiting a tardy roentgenogram, and an anesthetic is often necessary to relieve spasm and pain and give muscular relaxation. Reduction is produced by extension and counterextension of the fragments, with local manipulation at the point of fracture. Immediate reduction, before hemorrhage and edema interfere with manipulation, is most desirable.

Seven days after fracture a tenacious callus has formed, which often invades surrounding muscles, interferes with traction, and prevents reduction if there

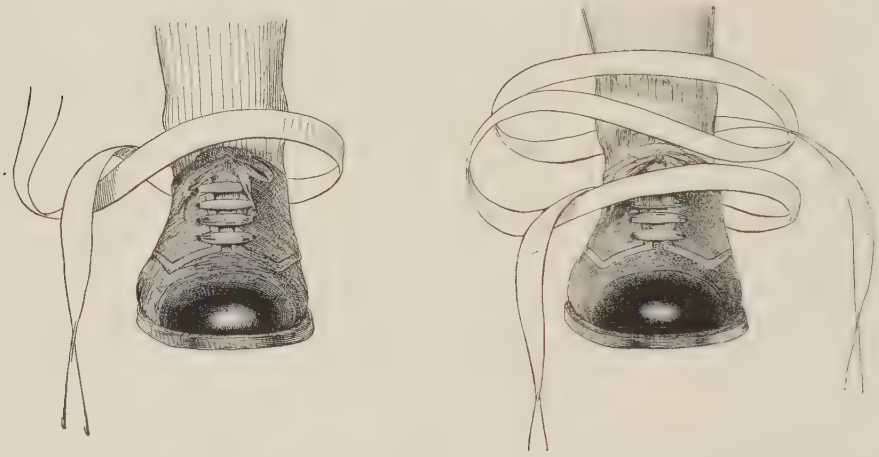


Fig. 106.—Collins' hitch used for making temporary traction in fracture of the leg, especially for field transportation in conjunction with a Thomas splint.

is overlapping of fragments, although lateral angular motion is present. Fifteen days after the fracture, ossification is fairly marked, and reduction is very difficult. The callus which invades surrounding muscles is a globular mass, not clearly defined, but containing gritty particles. If scraped with a sharp instrument, the gritty feel of early ossification can be detected.

3. **Position.**—The fracture having been reduced, the part should be placed in the *optimum position for retention* and, if a joint is involved, in the *optimum position for ankylosis.*

Position of Optimum Function in Ankylosis: Much disability may be prevented by keeping joints, that may become ankylosed, in the position of greatest usefulness. We are indebted to Robert Jones for his studies on this subject.

Shoulder-joint: The arm should be treated in an abducted position of about 50 degrees with the elbow slightly in front of the plane of the body.

Elbow-joint: An angle of about 70 degrees is the most useful position,

unless both elbows are involved; when *one* should be fixed at an angle of about 110 degrees, and *the other* at 70 degrees.

Forearm: The preferred position is a neutral one, between pronation and supination. For certain laborers, complete supination is desirable. Pronation is the position of least usefulness.

Wrist-joint: All injuries to the wrist-joint should be treated in a position of dorsiflexion, which improves the grasp of the fingers (*cock-up splint*).

Hip-joint: Ankylosis is least disabling with the leg in very slight abduction, the thigh being extended and rotated slightly outward.

Knee-joint: The knee-joint should be fixed in an extended position, or at an angle of 70 degrees.

Ankle: The foot should be kept at right angles with the leg, and in a slightly varus position. The normal arches of the foot should be supported, and slight inversion should be maintained, to give a stronger and more useful foot. The equinus position (*pointed toe*) follows contraction of the muscles attached to the *tendo achillis*, unless the foot is properly supported, and causes much disability.

Fig. 107.—Hawley's fracture table for operations upon bones and the application of fixed dressings to various parts of the body, under extension and fixation.

Reduction should be controlled and checked by Roentgen-ray examinations.

4. **Retention** or **fixation** of the fractured bones in proper position is obtained by splints and other supportive or immobilizing appliances, and by traction. In "War Surgery," fixation upon the battlefield before transportation proved of utmost value, preventing shock, pain, and complications from the shifting and movement of the ends of the fractured bone. Of the greatest value was the Thomas traction leg-splint. It was found that the leg and arm splint, the Jones cock-up "crab" wrist-splint, the long interrupted Liston splint with adjustable foot-piece, the Hodgen anterior thigh-and-leg splint, the Cabot posterior wire-splint, with wire ladder splint material, light splint wood, plaster-of-Paris bandages, and Bradford frames, made possible the efficient treatment at the front and in base hospitals of all bone-and-joint battle casualties. On practical application, seven of these splints were found to fill nearly every need. The results obtained in the fractures of the war compared more than favorably with those usually obtained in civil practice.

The minimum hospital requirements for transportation and emergency treatment of fractures, suggested by the Fracture Committee of the American College of Surgeons, are as follows:

1. Thomas' upper-extremity splint.
2. Thomas' lower-extremity splint, with traction-straps, slings, and buckled straps.
3. Hodgen's splint.
4. Coaptation splints of assorted sizes.
5. Cabot's wire splint.
6. Straight pieces of wood of assorted widths and thicknesses.
7. Plaster-of-Paris bandages.
8. Overhead bed-frame for suspension and extension.
9. Suitable *x*-ray apparatus, including a portable machine if practicable.

A special record sheet should be used for cases of fracture.

5. **Traction** may be: (1) *External* or *skin traction* through bands of adhesive plaster or strips of cloth or other material glued to the skin, with attached

Fig. 108.—Thomas' upper-extremity splint, hinged.

weight extension, as in Buck's extension, or by counterpressure, as with the Thomas splint; or (2) *internal* or *skeletal traction*.

Skin Traction in Fractures.—The traction (a) should be applied to the skin to a point slightly above the line of fracture; (b) should not be applied through

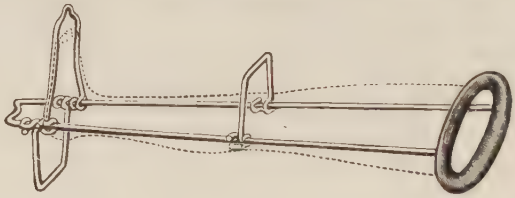


Fig. 109.—Thomas' lower-extremity splint.

joints, for fear of stretching the articular ligaments, with secondary looseness and disability.

1. *Zinc-oxid adhesive plaster* should be carefully watched when used, as it irritates many skins. The so-called "mole-skin" adhesive plaster, which has a

Fig. 110.—Thomas' half-ring leg-extension splint.

canton-flannel backing, is more elastic and conforms better to the surface than the ordinary plaster. These plasters are best removed from the skin by oil of wintergreen.

2. *Resin plaster* (used formerly) is much less irritating to the skin than the rubber-surfaced plasters, but it does not adhere as well. The plaster should be

cut in suitable strips and made adhesive, immediately before use, by pouring hot water over its face.

3. *Flannel traction-strips* glued to the skin by Heusner's or Sinclair's glue, which requires heating, may be used. By painting Sinclair's glue with a 2 per

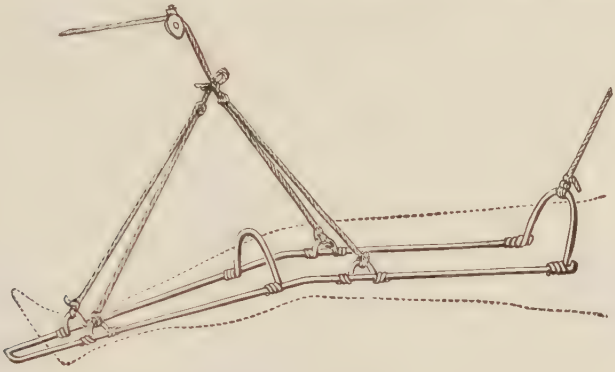


Fig. 111.—Hodgen's splint.

cent. solution of potassium bichromate the preparation becomes water-proof. The bichromate should be applied in the dark, and the part afterward exposed to the light.

Fig. 112.—Cabot's posterior wire leg-splint.

Glue adhesion is effective for two to four weeks, and much more rarely produces skin lesions than does adhesive plaster.

Heusner's glue:

Resin	50
Alcohol	50
Benzin (pure)	25
Venice turpentine	5

The glue is applied to the skin with a brush, the traction-strips applied and bandaged over the sticky layer, and complete evaporation (to avoid skin irritation) permitted before an outer impermeable dressing is added. The glue may be removed by benzin, alcohol, or oil of wintergreen.

Sinclair's glue (modified):

Isinglass	50
Glue	50
Water	50
Calcium chlorid	2
Tannic acid	12
Thymol	1
Glycerin	2

For use, melt in water-bath and apply with the palm of the hand or a brush, without shaving the part. It may be removed with water.

Technic.—In using Sinclair's glue the skin should not be shaved, but washed with an alkaline soap and hot water, the skin dried and the warm glue applied evenly with a shaving brush, brushing all the hairs on the limb in an upward direction. Traction-strips may be made of 8 layers of gauze or 2 or 3 layers of stockinette. These are carefully applied, and neatly coapted to the limb by a well-applied roller bandage or an elastic cotton stockinette covering.

Skeletal traction is applied directly to the bone, distal to the fracture, and has the following advantages:

1. Force is applied directly to the bone where it is most desirable.
2. Point of contact is small, permitting massage, passive movements, and

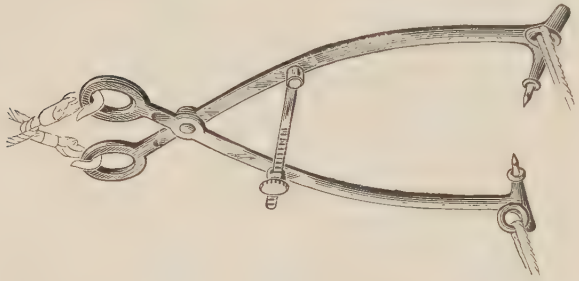


Fig. 113.—Beasley-Cannaday extension tongs for skeletal traction.

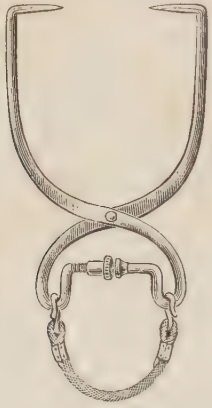


Fig. 114.—Edmondson fracture extension tongs.

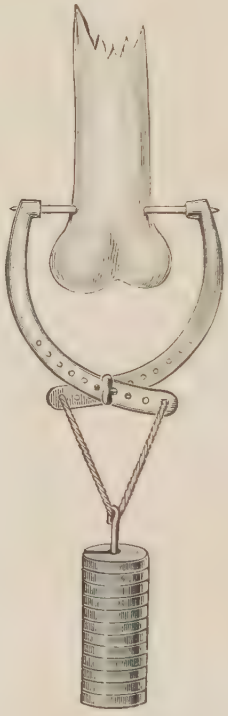


Fig. 115.—Steinmann's extension pin apparatus.

the like, of adjacent portions of the limb, and the convenient dressing of compound fractures.

3. Movement of the joints above and below the point of fracture does not interfere with the treatment. Unless there is skin tension or infection skeletal traction is no more painful than skin traction.

For the best results *all traction should be made in the axis of the proximal fragment when it is in the position of relaxation.*

Varieties.—Steinmann's transfixion pin or nail transfixes the bone just above the distal joint, and is attached to an extension device by rope and pulley. In introducing transfixion pins, the skin is pulled upward as the pin is introduced.

The point of election for the femur is just above the condyles, at the junction with the shaft. The lower cancellous bone yields to pressure, and the synovial membrane may be damaged. Transfixion of the tibia is made in the shaft just behind and below the tubercle. The pin, with proper care, can be left in place for two or three months if necessary. For both bones of the leg, transfixion is made 3 fingerbreadths above the tip of the external malleolus. Or, which is preferable, the pin is passed 2 or 3 cm. behind the tip of the external malleolus over the calcaneus. Transfixion of the olecranon is rarely required, except for certain fractures at the lower end of the humerus.

Ice-tongs or *bone traction clamps* (Pearson's, Adams', Dorrance's calipers) have sharp steel points which are pressed into the bone. They may slip, lacerating the soft tissues or opening the joint. As the bone is not perforated, the apparatus is less secure than Steinmann's pin.

Os calcis or *Finochetti stirrup* (or Chutro's modified stirrup) consists of a U-shaped steel band, passed over the posterior process of the calcaneus between

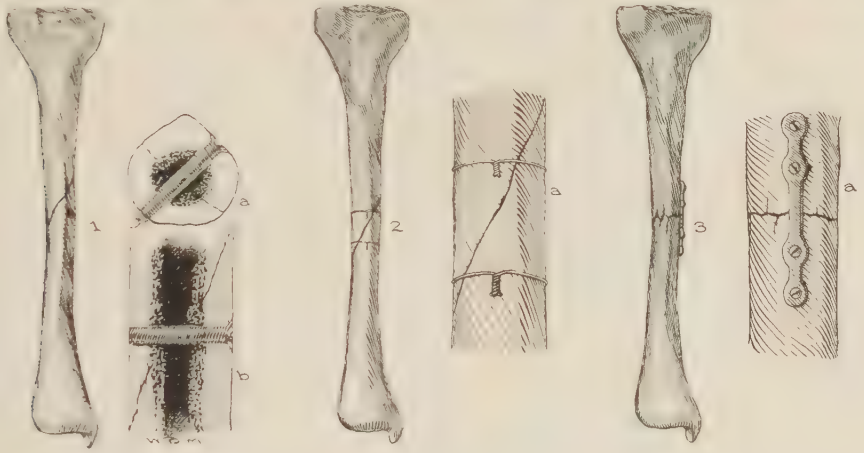


Fig. 116.—Internal fixation of fractured bone: 1. Fixation of oblique fracture by screw or bolt made of metal or bone. 2. Fixation of oblique fracture by two wire bands made of silver, steel, or aluminum bronze. 3. Fixation of transverse fracture of tibia by the steel plate of Lane. All of these devices are easily displaced, are readily loosened, and for retention external support is required. Metallic foreign bodies used for internal fixation later often require removal.

the tendo calcaneus and the ankle-joint, then fixed to a cross-bar from which extension is made. It is more painful and less desirable than the Steinmann pin.

Disadvantages of skeletal traction are the dangers of sepsis, osteitis, and arthritis, and damage to the joint, epiphysis, soft tissues, or nerves from the slipping of the apparatus. It rarely should be continued over six weeks. The adjacent skin is cleansed with alcohol, kept painted with compound tincture of benzoin or, if irritated, coated with 50 per cent. bismuth subiodid in petrolatum.

Operative Treatment of Fractures.—The eighth day after the injury is the best time for treating closed fractures by operation. At this time the tissues have largely recovered from the primary traumatism, and are in condition to withstand the added insult of the operation, while after the tenth day the parts are set in callus and granulation tissue, and the operation will more seriously

interfere with the reparative process. Open operations aim at the exact replacement of fragments, reduction being maintained by various devices, as follows:

Wiring.—Aluminum bronze wire is preferred on account of its strength and resistance to corrosion. Annealed steel wire may be used where aluminum bronze wire is not available, for, although it oxidizes in the tissues, it has a strength which silver wire lacks.

Nailing.—Nails of living or boiled bone, ivory, bronze, steel, silver, or other metal may be used. Nailing is chiefly employed to hold separated fragments about joints, as in fractures of the condyles of the humerus or of tuberosities. Nailing is at times valuable in fixing the lower fragment of the fibula in Pott's fracture, and in holding the fragments in alignment in fracture of the neck of the femur. Instead of nails, screws or bolts with threaded nuts may be

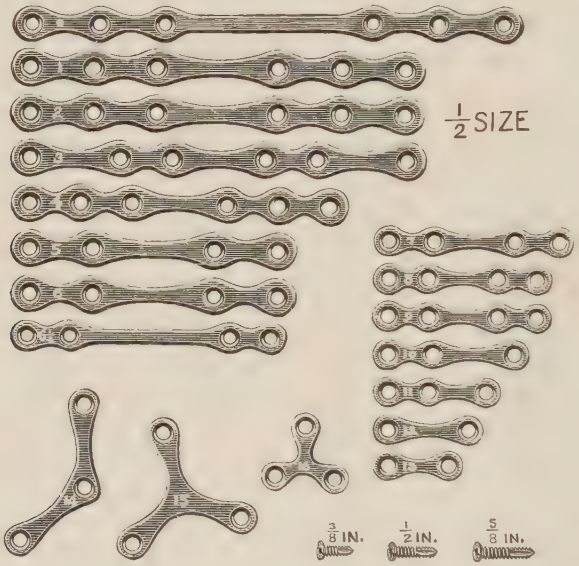


Fig. 117.—Lane-Sherman vanadium-steel plates and tap-screws.

employed. Screw-holes are drilled in bone with a suitable tap, or are made in the introduction of the screw. *Nails*, *screws*, and *bolts* (unless of homologous living bone) *soon loosen* by the absorption of the adjacent living bone, and *should not be depended upon for support.*

Plates.—The bone fragments may be fastened together by internal plates of metal, ivory, or dead or living bone. Metal, bone, or ivory pegs, nails, or screws may be used to fasten the plates in position. Plates are laid upon, inlaid, or dovetailed into the fragments. The preferred material is living bone, taken from the same patient. Dead bone (boiled bone), ivory, and metal plates are tolerated by the tissues in the order given. Steel plates (*Lane's plates*, *Sherman's vanadium-steel plates*) frequently have to be removed by a second operation, and may delay union or produce local irritation. They have the advantage of availability and ease of application, but during the last few years

have been largely discarded. Magnesium plates (suggested by Payr), while absorbable, produce adjacent tissue reaction and are not advised.

External Plates or Clamps.—Adjustable plates lying external to the skin, and fastened to the fragments by screws or bolts that pass to the bone through the partially closed wound, have been devised by Parkhill, Keatley, Freeman and Lambotta, but necessitate an external communication with the area of fracture, favoring infection, are of limited strength, soon become loosened, favoring displacement, and are rarely used.

Bands.—The *band of Parham-Martin*, made of annealed steel, is passed around the fracture, the tongue end being passed through a slot at the other end of the band, the band tightened and clamped about the fracture by a special instrument, and the surplus metal cut away. It is occasionally used for splinting oblique fractures.

Sliding Bone-inlays.—Bone inlays from one of the fragments, or a transplant taken from the tibia, as advised by Albee, produce the least irritation and best fulfil physiologic indications. Bone transplants should

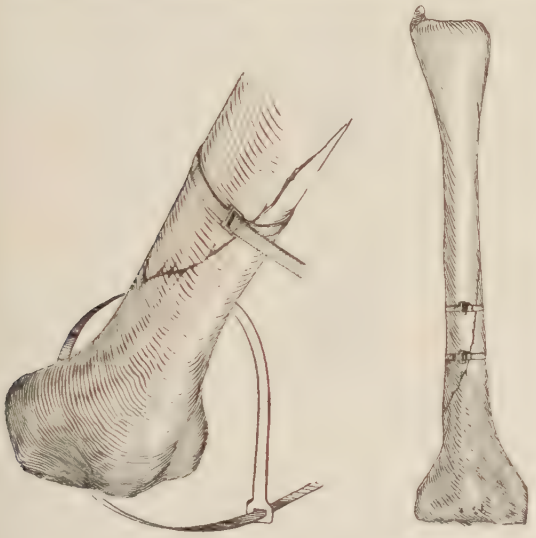


Fig. 118.—Application of single or double Parham-Martin band for oblique fracture.

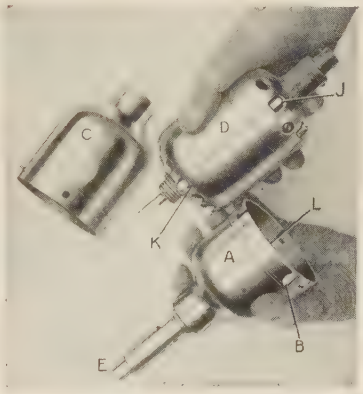


Fig. 119.—Albee's bone-motor (D) with removable, sterilizable shell (A, C) for motor-driven bone-saws, drills, burrs, and the like.

not be devitalized in their removal, and should have living periosteum and endosteum attached. They are fixed in position by sutures of kangaroo tendon, wire, or catgut, or by bone pegs, or nails and wedges of living bone. With a large defect, strips of periosteum with attached scales of bone may be stretched across the gap or wound about the fracture (Codivilla).

Treatment of Compound Fractures.—1. **Primary Closure.**—If seen within twelve hours from the time of injury, the wound area should be carefully disinfected, and devitalized, and dirt-impregnated tissue débrided by a very sharp knife, careful hemostasis obtained, and immediate closure completed. No foreign body for the internal fixation of fragments should be left in the wound. In the wounds of The War, as high as 80 per cent. of compound fractures were successfully treated in this way, and results should be better in civil practice.

2. **Delayed Primary Closure.** If not suitable for primary closure, the wound is cleansed, débrided, left freely open, and is carefully treated by the Carrel-Dakin method. Infection in the wound is determined by the daily enumeration of bacteria found in the wound secretions, by staining smears or by plating in Petri dishes. When there is an average of less than 3 bacteria to each microscopic field, the wound is closed. By this method compound fractures may be closed from the fourth to the eighth day.

3. **Secondary Closure.**—A delayed primary closure not having been accomplished, the case can be considered only for secondary closure. The wound having been freely opened, and all dead and devitalized tissue removed, it is very carefully treated by the Carrel-Dakin method. When relative sterility has been produced (as shown by bacteriologic tests for three successive days), the soft parts are closed over the fracture.

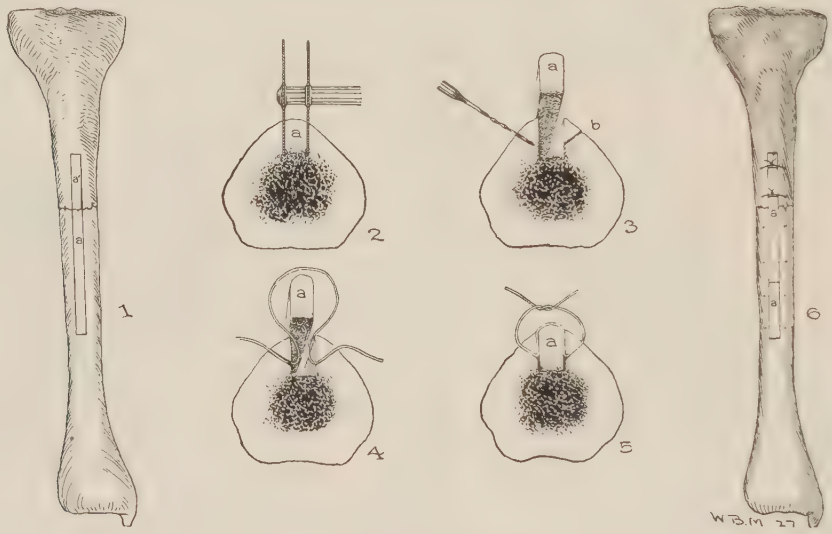


Fig. 120.—Albee's sliding bone-graft: 1. Transverse fracture of tibia with outline of bone-graft. 2. Separation of bone-graft by twin motor-driven circular saws. 3. Removal of graft and drilling of bone for retention sutures. 4 and 5. Methods of fixing graft by sutures of kangaroo tendon or chromicized catgut. 6. Sliding bone-graft in place, the upper two retention sutures having been inserted and tied.

For chronic septic osteitis with sinuses, a late secondary closure may often be quickly and more surely accomplished by the zinc-chlorid method of Babcock. A tourniquet is used to exclude the general circulation from the part, the wound and all sinuses are injected with a saturated solution of zinc chlorid. If a tourniquet cannot be used, the sinuses are packed with cotton pledgets impregnated with the zinc solution. The adjacent field is very carefully disinfected. Recesses and sinuses are then injected with a solution consisting of: Caustic potash, 3; phenol, 5; saturated alcohol solution of methylene-blue, 20; and sufficient ether to make 100 parts. The tourniquet, which prevents the entrance of the caustic into the general circulation, may now be removed. All sinuses are completely excised, all blue-impregnated tissue and bone in every recess freely removed, and the bone so contoured that no deep cups, holes, grooves, or

recesses remain. The adjacent muscles are liberated, united over the bone, and the wound closed without drainage. Complete union of the skin is omitted if this causes tension. *It is very important that every bit of tissue impregnated with the caustic be excised, so that progressive erosion which might damage blood-vessels or nerves cannot occur.*

Ununited Fractures, Delayed Union, and Non-union of Fractures.—*Delayed union* refers to absence of union beyond the normal time. *Non-union* is a more chronic condition with absence of any evidence of bony union of the fragments. The presence of chronic fibrous union, a false-joint, or interposed soft tissues is proof of non-union.

Etiology.—(1) Separation of fragments or interposition of soft tissue. (2) Excessive movement or absolute immobility. (3) Defective blood-supply. (4) Disease of the bone—malignant, pyogenic, syphilitic, or tuberculous. (5) *Location:* Bones like the humerus, difficult to mobilize, are the most common seats of non-union. The bone may show atrophy, hyperplasia, or special disease, as gumma or sarcoma.

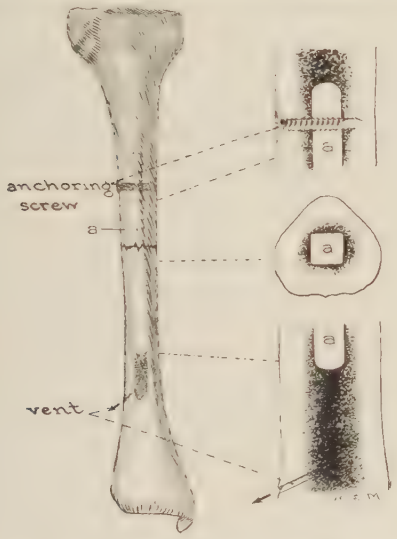


Fig. 121.—Use of intramedullary bone-peg for fracture of a long bone; to prevent the displacement of the peg from medullary effusion the marrow cavity should be vented beyond the ends of the peg, or the peg anchored by a screw or other device. A square peg has the advantage of not completely occluding the lumen.

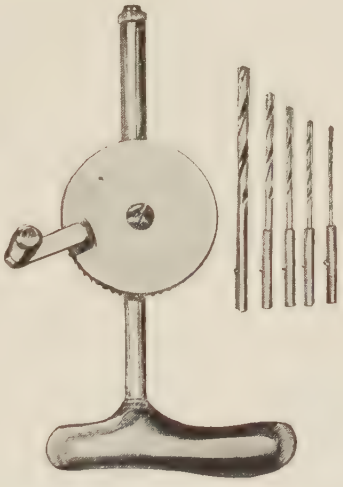


Fig. 122.—Bone drills and handle.

Treatment.—The following methods are employed: 1. *Friction:* Massage of the overlying skin.

2. *Passive hyperemia* after the method of Bier. An elastic band is placed around the limb above the fracture, sufficiently tight, so that the part develops a warm painless swelling. If the part below the constriction becomes cold, blue, and pale, the band should be removed.

3. *Local Irritation.*—The fractured ends are rubbed together, percussed with a padded mallet, or limited weight bearing in a support used.

4. *Injection of Blood* (Bier).—Five to 20 c.c. of blood are withdrawn from a convenient vein, reinjected through a strong hypodermic needle

between and around the fractured ends, and the bones carefully immobilized.

5. *Subcutaneous drilling of the bone ends* by a long thin drill thrust through the skin.

6. *Autogenous bone-graft*, or transplant of bone with attached periosteum and endosteum, is the most effective method for overcoming non-union. In all cases constitutional disease, as syphilis, rickets, scurvy, should be recognized and appropriately treated.

Massage is started, without removing the retention splint, on the second to the nineteenth day, dependent on the character of the fracture. With a bivalved plaster case, the upper half is removed to give access to the part. Massage stimulates the vascular and lymphatic circulation, improving the local nutrition, and, by abolishing muscular spasm, permits early movement without displacement of fragments.

Massage should be graduated, carefully supervised, and should relieve pain, otherwise it is not properly performed. The part should be well supported by splint, sand-bags, or firm pillows in a position of relaxation and comfort. The treatment should begin with superficial, gentle, slow, rhythmic stroking movements, without pressure, proceeding from the periphery toward the center, and avoiding the immediate neighborhood of the fracture. From five or ten minutes a day the treatment may gradually be increased to twenty, forty, or fifty minutes, progressing to deeper pressure and, finally, to kneading movements. Early in the treatment gentle supported passive movements are used, followed, as union occurs, by guided and supported active movements, and finally, when union is firm, by unaided active movements. None of these movements should be painful. Later the patient is encouraged to gradually contract the adjacent muscles, and to actively move the joints without resistance.

SPECIAL FRACTURES

The **nasal bones** are broken by direct violence, from blows, falls upon the nose, or, more rarely, from a general crushing injury of the face. The fracture is commonly compound in the nose, but rarely compound through the skin of the face.

Symptoms.—Depression, lateral deviation of the nose with nose-bleed and interference with nasal breathing, and crepitus, best elicited by gentle pressure. A secondary swelling rapidly follows, which obscures the deformity so that the fracture is frequently overlooked until months or years later, when a deviated septum or deformity of the nose attracts attention. The septum and the lower third of the nasal bone are most frequently broken. Complications, such as emphysema, infection, or necrosis, are rare, although, in the syphilitic, necrosis is to be feared and should be prevented by appropriate treatment. Especially serious is a complicating fracture of the anterior fossa of the base of the skull, which may lead to meningitis and death within a few days.

Treatment.—As soon as possible after the injury examination should be made, as the bones rapidly unite in malposition. A 10 per cent. solution of cocain in 1 : 100 epinephrin solution is applied to the mucous membrane to arrest bleeding, reduce swelling, and give anesthesia. The position of the septum and

the condition of the interior of the nose are then carefully determined. Depressed nasal bones are raised into position by introducing the little finger, a hemostat, or other smooth instrument into the nose, the deflected septum straightened, and the contour of the external nose restored. The parts are maintained in position by intranasal splints or a packing of subnitrate-of-bismuth gauze, assisted by external support (pads, adhesive plaster, or a molded splint of plaster, celluloid, or vulcanite). For low deviation Asch tubes may be introduced into the nostrils, and the crushed nose molded over them. In severe cases, to maintain the elevation of the depressed fragments, a strong (Mason's) pin may be passed through the nose and septum at the attachment of the nose to the cheek and figure-of-8 turns of thread taken over appropriate pads, and passed around the projecting ends of the pin and over the nose. The free use of bismuth subnitrate or bismuth subiodid on the mucous membrane is useful to prevent infection or middle-ear disease. Union occurs in from ten days to two weeks, and retentive appliances may be removed in from seven to ten days. Deflection of the nasal septum is a common residual deformity, and can be corrected by a limited submucous resection. Changes in the external contour of the nose may later be corrected by the subcutaneous implantation of cartilage, or by plastic operation.

Lacrimal bone is rarely broken without associated fracture of the adjacent bones. The chief complication—obstruction of the lacrimal duct—is to be prevented by the replacement of fragments, and the use of Bowman's or Theobald's probes during the period of union.

Zygomatic (malar) bone is broken by direct violence upon the cheek, portions of the bone usually being driven in and impacted, with loss of the malar prominence, orbital and conjunctival hemorrhage and, rarely, impingement on the coronoid process, interfering with the movements of the lower jaw. A unilateral irregularity of the orbital margin with local tenderness is diagnostic. If the infra-orbital nerve is implicated, paresthesia along the upper gum, the skin of the cheek, nose, and upper lip is present.

Treatment.—Replacement by fingers in the mouth and on the cheek (using the edge of the anterior part of the zygoma and the orbital ridge for leverage) should be tried. If this fails, and the deformity is not objectionable to the patient, the impaction may be ignored or, through a minute incision made by a tenotome, a screw or tap is firmly set into the bone, which is then lifted into proper position, the screw removed, and the minute opening closed by a horsehair stitch. As there is no tendency for displacement, retentive dressings are not required. Union occurs in two weeks.

Zygoma is usually fractured by direct violence in its middle third, directly behind the zygomatic bone. Reduction is effected by pressure of the fingers from within the mouth and externally. Open reduction of the fragments, with wiring or ligation of the fractured ends with kangaroo tendon or catgut, is sometimes desirable. If there is a tendency to displacement, the lower jaw should be fixed by a Barton or Gibson bandage for two weeks. Union occurs in from two to three weeks.

The **maxilla** is usually broken by direct violence or, rarely, indirectly by a force applied through the chin or the mandible. As a rule the fracture is com-

pound, comminuted, bilateral, and associated with fracture of adjacent bones. A transverse fracture occurs, with separation of the alveolus and contained teeth. The teeth are often loosened, and the invasion of the maxillary sinus is common. The symptoms are malocclusion of the teeth, mobility of the teeth and the alveolus, subcutaneous emphysema from escape of air from the antrum, and neuralgic pain or anesthesia from injury of the infra-orbital nerve.

Complications include fractures of the adjacent bones, of the base of the skull, with meningitis, laceration or occlusion of the lacrimal duct, and secondary sinusitis, purulent osteitis, and necrosis. Perforation of the hard palate, caused by a child falling with a stick or a pencil in the mouth, may be followed by a naso-oral fistula.

Treatment consists of early disinfection of the mouth and nares, and reduction of the fragments. Retention is best obtained by fastening the jaws in accurate occlusion, by wiring the teeth, or by a dental appliance, with the external support of a Barton or Gibson bandage. The removal of teeth, or the separation of the jaws by an interdental splint, for feeding is unnecessary and undesirable. If the patient has been accustomed to an artificial denture or plate, it is worn during the early period of healing to maintain the fragments in position. A dentist should co-operate in the treatment, the hygiene of the mouth being carefully maintained, and adequate drainage provided if suppuration occurs.

The **mandible** is usually broken by direct violence (seldom by an indirect force) compressing the body of the jaw and producing a vertical fracture near the midline. A fall or blow upon the chin may cause a fracture of the condyle.

Varieties.—The most common fracture is vertical, occurring in the body between the bicuspid and the mental foramen. Fractures of the lateral portion of the body of the jaw and of the ramus behind the angle are occasionally observed. Fractures of the condyle and coronoid process are rare.

Symptoms.—Fractures of the body are characterized by irregularity and malocclusion of the teeth, deformity, and crepitus. Usually the fracture is compound into the mouth. There is a tendency for the anterior fragment to be drawn downward, the posterior fragment upward. If the fracture is in front of the masseter, the posterior fragment is pulled upward by the masseter and temporalis, while the genioglossus and geniohyoideus, the anterior part of the mylohyoideus, the digastricus, and the platysma drag the anterior fragments downward and backward. With fracture of the neck of the condyle the jaw is drawn toward the injured side by the pterygoids, the condyle pulled forward and medially by the external pterygoid. With fracture of the coronoid displacement is usually slight, because the temporal muscle is attached farther down on the inner than the outer side; but, if the medial fibers are torn through, the process is drawn upward by the temporal muscle.

Complications.—Osteitis and necrosis, with possible secondary pneumonia or pyemia, cervical adenitis, spreading abscess of the neck, and cachexia from prolonged suppuration. The force transmitted through the condyle may lead to fracture of the base of the skull.

Treatment.—Disinfection should be followed by careful reduction. In fractures of the body of the mandible, reduction is shown by the accurate occlusion of the lower with the upper teeth. This is maintained by wiring the upper and

the lower teeth together, or by the use of Angle's bands or similar appliances. The additional support of a Barton or Gibson bandage should be used. An interdental splint with separation of the lower and upper jaws should not be used, as it tends to cause deformity with malocclusion. The splints of Moriarty, Kingsley, and Matas are of historical interest. If the teeth have been lost, a denture previously worn or a special support constructed by a dentist should be used. The wiring and plating of the bony fragments by open operation, particularly if the fracture is compound, is often followed by infection and necrosis, and, as a rule, is to be avoided as a primary operation. The Hammond wire-splint is occasionally of value. It consists of a U-shaped inner and a U-shaped outer loop of strong wire bent to conform to the necks of the teeth, the two loops being fastened in position by fine wires passing between the teeth. The

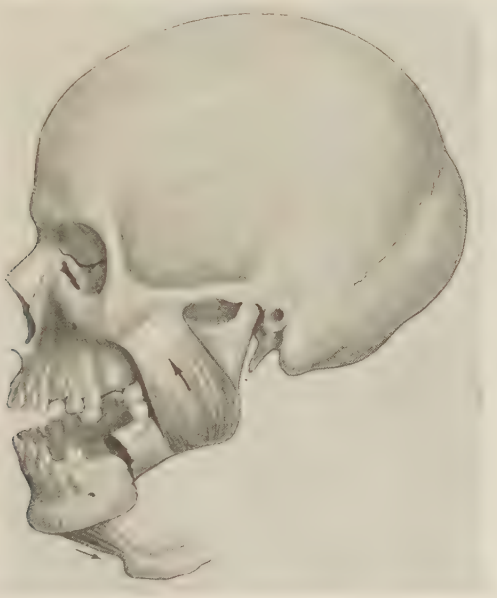


Fig. 123.—Fracture of the mandible in front of the masseter with displacement of the proximal fragment upward by the masseter and temporalis, the anterior fragment downward and backward by the geniohyoideus, genioglossus, anterior part of the mylohyoideus, digastricus, and platysma muscles.

association of an orthodontist is very desirable in complicated fractures of the jaw. Union occurs in three or four weeks. If the bone becomes infected, discharging sinuses may continue for months, or even years, necessitating repeated operations to evacuate the pus, and maintain free drainage, or to remove sequestra.

Ribs.—The ribs are broken by indirect violence, the fracture occurring near the angle, or less often by direct violence. The fifth to the eighth ribs are most frequently fractured; the well-protected first and second and the mobile eleventh and twelfth rarely. Ribs may be fractured in a violent paroxysm of coughing, in asthmatic attacks, during an epileptic convulsion, from muscular strain, or from efforts at artificial respiration.

Symptoms.—There is pain on deep inspiration, coughing, or sneezing, with local tenderness and, possibly, slight swelling. Usually there is little displacement. In compressing the chest between the hands pain is referred to the point of fracture rather than the point of compression. By palpation or by a stethoscope crepitus produced by respiratory movements or pressure may be detected.

Complications.—Puncture of the pleura, lung, liver, or spleen; diaphragmatic hernia and secondary pleural effusion may occur; also surgical emphysema, which spreads from the chest over the body and spontaneously disappears after a few days. Hemoptysis indicates laceration of the lung. Hemothorax, pneumothorax, pleurisy, pneumonia, bronchitis, and empyema also follow the fracture.

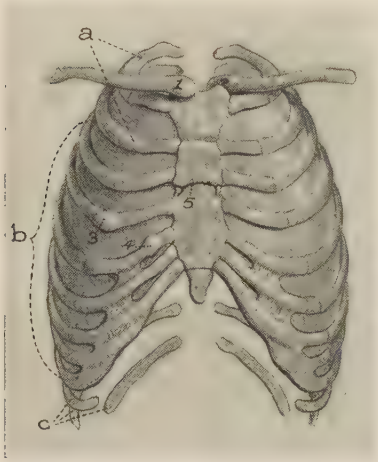


Fig. 124.—Injuries of the bony thoracic wall: *a* and *c*, Ribs infrequently fractured; *b*, ribs usually fractured, especially the fifth to eighth; *1*, anterior and *2*, posterior dislocation of the sternal end of the clavicle; *3*, costochondral separation; *4*, fracture of ossified costal cartilage; *5*, transverse fracture of the sternum.

Treatment.—Usually there is little displacement, so reduction is not necessary. Fixation and support of the affected half of the chest is obtained by adhesive-plaster strapping and a circular bandage. After shaving the chest, overlapping strips of adhesive plaster (about 7 cm. wide) are so placed as to cover the affected side of the chest and about one-third of the opposite side. For better fixation the strips are applied from below upward, and during expiration. Over the adhesive a roller bandage or a snug binder is placed. If there are complications, the patient should remain in bed. Rarely open reduction is indicated for marked displacement which cannot be corrected by external manipulation and deep inspiration. The strapping may fail to relieve the pain: Because the entire side of the chest is not sufficiently immobilized; because the ends of the bone are driven together by too much pressure; or because of marked displacement or other complications. In such cases the dressings should be removed, and appropriate treatment instituted. Opiates may be used to relieve pain, and to prevent excessive respiratory movement and coughing.

Costal cartilage usually separates at the attachment to the rib, but occasionally, especially with the calcification of age, fracture occurs. Crepitus is absent when the cartilage is calcified. Union occurs by ossification.

Symptoms and **treatment** are similar to those for fracture of the ribs.

Sternum.—Although usually broken by direct violence, the sternum may be broken by indirect force through extreme flexion or extension of the body. In most cases the line of fracture is at the junction of the manubrium with the gladiolus, the upper fragment passing behind the lower fragment and occasionally compressing the trachea, with dyspnea or, more rarely, with injury to the aorta.

Symptoms.—As a rule the body is bent forward, with deformity from the projecting upper end of the lower fragment. There is abnormal mobility, occasionally crepitus, and frequently, dyspnea and painful cough.

Complications, which are often associated, include fracture of the ribs, injury to the thoracic viscera and, as secondary complications, necrosis of the sternum, mediastinitis, and aneurysm of the aorta.

Treatment.—Reduction is attempted by hyperextension of the spine as the patient takes a deep inhalation, and pressure is made over the protruding lower fragment. Or, the patient is placed supine upon a table, with his head and shoulders extended over the edge. An assistant steadies the body while the operator, facing the vertex of the patient, raises the patient's arms above the head, and

Fig. 125.—Usual displacement in fracture of the clavicle, the inner fragment is tilted up by the sternocleidomastoideus, the outer fragment depressed, tilted down, and carried inward by the weight of the arm and contraction of pectorals, teres major, and latissimus dorsi.

slowly rotates them upward and outward until reduction occurs. Adhesive strapping is then applied. Open reduction is indicated if there are pressure symptoms and if reduction by manipulation fails. Union occurs in four to six weeks. The patient should be kept on his back in bed for three weeks.

Clavicle.—Excepting the radius, the clavicle is more frequently broken than any bone in the body.

Etiology.—The clavicle, the only bony connection between the upper extremity and the body, is usually broken by indirect violence, through falls upon the outstretched hand, or blows or falls upon the shoulder. Its exposed position also favors fracture by direct violence.

Varieties.—1. *Sternal End:* There is little displacement, the inner end possibly being drawn up.

2. *Middle of the Clavicle:* This is the usual situation, the fracture occurring about the junction of the middle and lateral third, where the two curves of the clavicle meet and the bone is thinnest and has the least muscular attachment. The fracture line runs backward and mediad; the lateral end of the medial fragment is tilted up by the sternocleidomastoideus; the lateral fragment is depressed, tilted down, and carried mediad, largely by the weight of the arm; the shoulder being displaced downward, mediad, and forward by the contraction of the subclavius, the pectoralis minor, teres major, and latissimus dorsi. The patient inclines the head toward the affected side to relax the sternomastoid, and supports the drooping shoulder by the opposite hand under the elbow.

3. Fracture *between conoid* and *trapezoid ligaments* is produced by direct violence, with little displacement.

4. *Acromial End:* Here the fracture results from direct violence; there may be little displacement, or the lateral end may be carried downward and forward.

5. *Greenstick fracture* of the clavicle is common in children.

Diagnosis of the usual fractures of the clavicle is easily made, as the deformity, crepitus, preternatural mobility, local tenderness, disability, posture, and position of the affected arm are very evident. If the result of direct violence, a bruise may be present over the fracture.

Complications—including compound fracture, injury of the subclavian vessels, brachial plexus, pleura, or lungs—are all rare. From injury to the subclavian artery, secondary thrombosis, traumatic aneurysm, and gangrene of the arm occur.

Prognosis.—Union, with some deformity but good function, is the rule. Non-union is rare.

Treatment.—Fractures of the sternal end between the fibers of the sternoclavicular ligament, and those at the acromial end, are treated by the application of a pad and adhesive strapping over the point of fracture, the arm being carefully supported by a well-applied Velpeau bandage. Fracture of the middle of the clavicle is easily reduced, but hard to retain. To maintain reduction the arm should be supported and the shoulder carried upward, backward, and laterad.

1. *Recumbent treatment* gives the best alignment and the least deformity, and is, therefore, used for women. The patient remains for three weeks on her back, on a firm bed or Bradford frame, with a sand-bag or firm pillow between the scapulæ, and with the arm held by bandage in the Velpeau position.

2. *Ambulant treatment* gives good functional result, with a deformity which attracts little attention in men: (a) *Clavicular cross* is a T-shaped splint made of two boards. The cross-piece is as long as the shoulders are wide, and about 12 or 15 cm. broad. The vertical piece extends from the vertebra prominens to the sacrum. The splint is heavily padded, the vertical piece strapped about the waist. From the ends of the heavily padded horizontal piece straps pass over the shoulders and through the axillæ. Anteriorly these straps are, by a third strap, kept from slipping laterally over the shoulder. The arms are left free, and movement permitted from the first. The cross is worn for four weeks. This is the preferred method of ambulant treatment.

(b) *Figure-of-8 bandage* on both shoulders, crossing over a heavy pad placed

in the interscapular space, is used particularly for infants. The bandage should be of soft lint, woven material, or flannel.

(c) *Sayre's dressing* consists of two strips of adhesive plaster, 7 or 10 cm. wide; at one end of the first strip a loop lined with lint is made, which is slipped about the arm half-way between the shoulder and elbow; this strip encircles the chest from the back, pulling the arm backward. The second strip is carried from the back of the affected shoulder, down the back of the arm, forearm, and hand; over the opposite shoulder, and obliquely across the patient's back, a hole having been cut for the olecranon. The first strip serves as a fulcrum; the second, by carrying the elbow forward and mediad, carries the acromial end of the clavicle upward, laterad, and backward. Apposing skin surfaces should be well dusted with stearate of zinc, and kept from contact by a layer of gauze, lint, or other material. The dressings should be revised at least once each week, and the skin carefully watched to prevent maceration, ulceration, pressure, or adhesive plaster irritation.

Retention is required for the first three weeks, and a supporting sling or bandage should be worn three to five weeks longer, when the patient should be able to return to work. Sayre's strapping usually gives perfect functional results, with some thickening and angulation, and an excess of callus from imperfect retention.

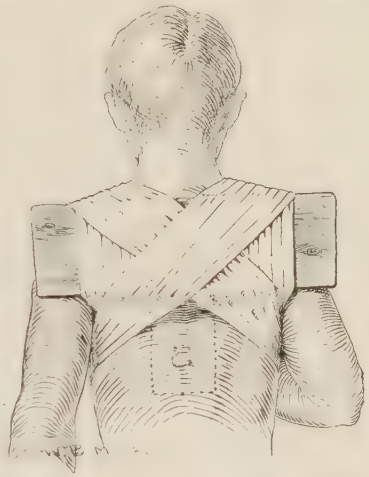


Fig. 126.—Clavicular cross. Should be well padded. The vertical extension, at times used, is indicated by *a*.

Open reduction with mechanical fixation is rarely indicated. An intramedullary peg of ivory or bone may be used, although the peg will break if sufficient external support is not provided. Metal plates and wires frequently become displaced and, if left in a subcutaneous position, as is usual, cause secondary irritation, so that a subsequent operation for their removal is required. A sliding bone-graft should only be attempted by the expert. The clavicle is seldom the seat of delayed union or non-union.

Scapula.—The *acromion*, *coracoid process*, and *body* of the scapula are fractured by direct violence. As a rule there is little deformity or crepitus, but local tenderness on pressure and pain on abduction of the arm, or in rotating the scapula upon the chest, are present. With fracture of the acromion there may be loss of abduction of the arm, some flattening of the shoulder, while abnormal mobility and crepitus may be demonstrated by pushing upward upon the elbow. Fractures of the body of the scapula divide the surgical or, more rarely, the anatomic neck. Those of the *surgical neck* run downward from the suprascapular notch, and include the coracoid process. There is limited displacement unless rupture of the coraco-acromial and coracoclavicular ligaments occurs, when the coracoid and glenoid are carried downward by the weight of the arm, with a deformity easily overcome by supporting the arm.

Diagnosis is made from dislocation by the movement of the coracoid on the scapula, the crepitus, and the tendency for the deformity to recur when the arm is not supported.

The *anatomic neck* is fractured as a rare complication of dislocation of the shoulder, and the fracture is frequently intra-articular. In these fractures the acromion is prominent; the arm lengthened, particularly with fractures of the surgical neck; and crepitus may be obtained by rotating and pushing the arm upward. There is an associated fulness of the axilla. Fractures of the glenoid may be present with fractures of the anatomic neck.

Prognosis.—Complete return of function after fracture about the shoulder-joint is delayed and uncertain, particularly in middle-aged or elderly persons. Chronic osteo-arthritis, adhesions about the joint, and traumatic neurasthenia are frequent sequelæ. Eight weeks to a year is often necessary before the patient can return to work, and the early and prolonged use of massage, baking, and other physiotherapeutic measures are desirable.

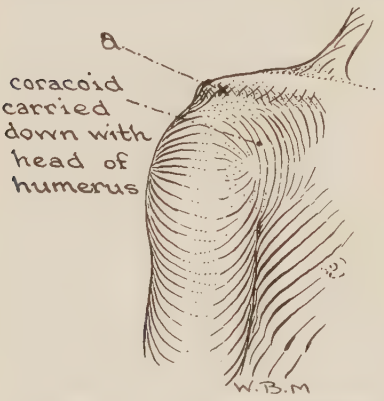


Fig. 127.—Contour of the shoulder with fracture of the neck of the scapula: *a*, Acromion process.

The **treatment** should include: (1) *Immobilization* of the scapula by bandage or strapping; (2) *elevation* and *fixation* of the arm to the side of the chest by a Velpeau bandage, with or without the third roller of Desault, with (3) a thin or thick *pad in the axilla*, as is required in the particular case. For fractures of the surgical neck of the scapula and the acromion reduction is maintained by keeping the humerus elevated, abducted, and rotated outward by an aëroplane splint or plaster bandage. If there is marked tendency to displacement, extension in abduction for three weeks by a Thomas splint may give the best results. The support should be continued for three to four weeks or, in fractures involving the neck of the scapula, for five weeks. A sling should be used for two weeks after the removal of the dressings.

Humerus.—Fractures of the humerus are very common, and are divided into those of the: (1) *Upper end*, (2) *shaft*, or (3) *lower end* of the bone.

Fractures of the *upper part of the humerus* involve (a) the anatomic neck, (b) the surgical neck, (c) the great tubercle, and (d) the upper epiphysis.

Anatomic Neck of the Humerus.—*Intracapsular fracture* occurs from direct violence, particularly in the aged. The line of fracture may extend beyond the capsule, but an attachment of the head of the bone to a part of the capsule is usual. Impaction is frequent, the arm may be slightly shortened, and it is difficult to obtain crepitus. There is great bruising, loss of mobility, and, through the axilla, the irregular or detached head may be felt. The swelling obscures any change in the contour, and there is pain upon movement. The shoulder is broadened. Gentle attempts to demonstrate abnormal motility or crepitus may be made by grasping the head of the bone while carefully

rotating the shaft from the elbow. Great care should be taken not to further lacerate the capsule or separate an impaction. Necrosis of the upper fragment is unusual.

Treatment.—Disimpaction or prolonged fixation are undesirable. The arm should be well supported by a sling or bandage, and passive movements and massage started from the third day. Stiffness and limitation of the movements of the joint, persistent pain, and atrophy of adjacent muscles are common sequelæ. To relieve pain and improve function an operation may be required to remove a loose fragment or to contour or resect the head of the bone.

Surgical Neck of the Humerus.—*Extracapsular fracture* usually occurs from direct or, rarely, from indirect violence in young or middle-aged adults. The fracture line lies below the tubercles, between the attachment of the short rotators and the pectoralis major, teres major, and latissimus dorsi.

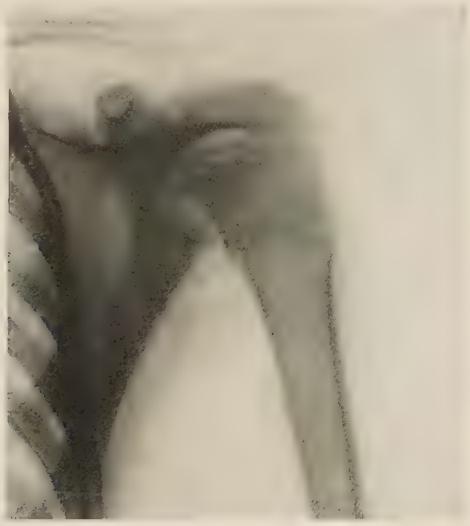


Fig. 128.—Impacted fracture of the surgical neck of the humerus. (Roentgenogram by Dr. G. C. Bird.)

Deformity.—The upper end of the lower fragment is carried into the axilla; being raised by the deltoid, biceps, coracobrachialis, and triceps; and drawn mediad by the pectoralis major, teres major, and latissimus dorsi. The upper fragment may be somewhat abducted by the supraspinatus, but is not rotated, as the internal rotatory power of the subscapularis from the front is balanced by the external rotatory pull of the teres major and infraspinatus from behind.

Symptoms.—The contour suggests dislocation of the shoulder, but on analysis, the outline of the shoulder is found unaltered, the depression being below the level of the shoulder. The end of the lower fragment may be felt in the axilla, and crepitus detected on rotation of the arm. The head of the bone is displaced, and does not rotate with the shaft of the humerus. There is marked shortening. Impaction at times occurs, with the lower fragment driven into the upper one. The diagnosis may be difficult without a Roentgen-ray examination.

Complications include associated dislocation of the head of the bone, and injury of the axillary vessels and nerves; particularly the axillary (circumflex) nerve, as it winds about the bone near the line of fracture.

Treatment.—Reduction is accomplished by manipulation and extension, an anesthetic often being desirable. Complete reduction should be proved by a roentgenogram, and maintained by axial traction in abduction (position of optimal function); the patient is kept in bed, and a straight Thomas arm-splint used for the first ten days. The elbow may be flexed or straight. After ten days the patient is permitted to be out of bed with an abduction arm-splint, the elbow being bent. The aëroplane splint of Jones, or a molded abduction-splint fashioned of plaster of Paris, may be used. Gentle massage should be started at the end of the first week, and carefully graduated passive movements from

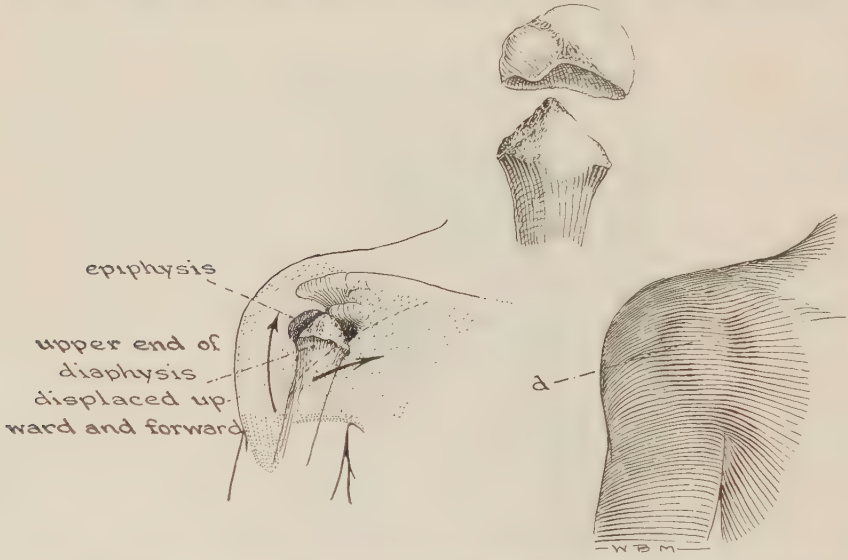


Fig. 129.—Separation of the upper humeral epiphysis, showing the normal cup and cone formed by the epiphysis, which may render reduction difficult but retention easy: *d*, Prominence from displaced diaphysis.

the end of the second week. A sling is substituted about the fourth week, and all supports removed after the fifth week provided good union has occurred.

The **prognosis** is good except in the elderly or rheumatic, who usually have much residual pain and stiffness.

Separation of the upper epiphysis occurs up to the twentieth year, chiefly in boys between the ages of five and fifteen. The upper end of the diaphysis is conical, and the epiphysis shows a corresponding concavity. The displacement is usually incomplete, owing to an attached bridge of periosteum which usually is posterior. The upper end of the diaphysis tends to project forward and mediad. There may be an epiphyseal strain without displacement.

The **symptoms** resemble those of fracture of the surgical neck, but the crepitus has a much softer quality. Reduction of the small cone of the diaphysis within the little cavity in the epiphysis may be difficult, but should be

complete to avoid arrest of growth of the arm. Traction with slight rotation should be tried, carrying the elbow forward and upward. If reduction is not obtained (shown by the roentgenogram), traction in abduction with a Thomas splint should be used for several days. An open operation is rarely necessary unless soft tissues are interposed. After reduction there is little tendency to displacement and, aided by the growth of the patient, little tendency to secondary fibrous ankylosis. A Velpeau bandage with a pad in the axilla is used for three weeks, followed by a sling for two weeks more.

Head of the Humerus.—Fracture is rare and occurs by direct violence. There is painful and restricted movement of the shoulder-joint, and effusion into the joint without shortening. A roentgenogram is required for a precise diagnosis.

Greater tubercle is broken by direct violence, or by muscular action from the attached supraspinatus, infraspinatus, and teres minor. The fracture may be a complication of a fracture through the neck of the humerus, or of an anterior dislocation of the shoulder.

Deformity.—The tuberosity, if completely detached, is carried upward and backward by the contracted supraspinatus.

The **symptoms** are swelling and widening of the shoulder, crepitus, loss of rotation of the arm, local tenderness, and pain on attempted abduction and rotation of the shoulder.

Treatment.—If there is no displacement, a pad should be strapped over the area of fracture and a Velpeau bandage applied. If the fragment is displaced upward and backward, the arm is to be fixed in abduction and external rotation by an aëroplane splint or plaster case. When, as often happens, this fails to give apposition, the fragments should be fastened in position by bone-pegs or screws through an incision. Fixation should be continued for four weeks. The functional result is usually good.

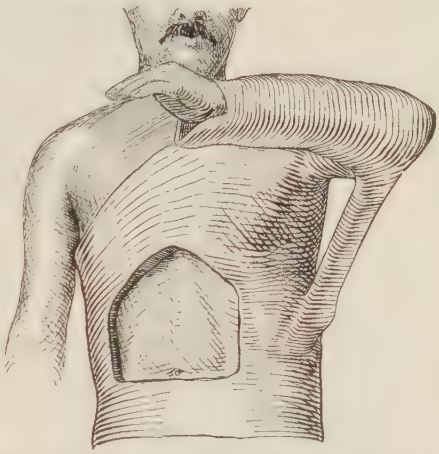


Fig. 130.—Aëroplane type of support of the arm, using plaster-of-Paris case.

Lesser Tubercle.—Only a few cases of this rare fracture are on record. As the attached subscapularis tends to pull the fragment mediad, the arm should be dressed in adduction and internal rotation.

Shaft of the humerus may be broken by direct or indirect violence, or by muscular action.

Symptoms.—The displacement varies with the situation of the fracture: (1) If below the insertion of the pectorals and above the insertion of the deltoid, the upper fragment is drawn mediad by the muscles attached to the bicipital groove—the pectoralis major, teres major, and latissimus dorsi. The lower fragment is drawn upward and laterad by the deltoid. (2) Below the insertion of the deltoid (which is the usual situation for fracture of the shaft) the upper

fragment is pulled laterad by the deltoid and supraspinatus, forward by the coracobrachialis and the anterior portion of the deltoid, and the lower fragment is carried mediad and upward. The line of fracture runs from above down-

Fig. 131.—Spiral comminuted fracture of the upper third of the humerus. (Roentgenogram by Dr. G. C. Bird.)

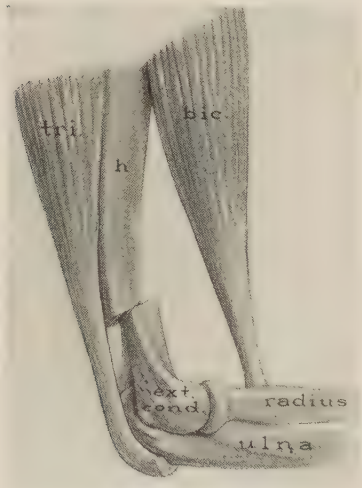


Fig. 132.—Flexion fracture of the lower third of the shaft of the humerus.

Fig. 133.—Extension fracture of the lower third of the shaft of the humerus.

ward and laterad. In the lower third the lower fragment may be drawn upward, in front of or behind the upper fragment, according as the fracture is produced by flexion or extension.

Complications.—Non-union is more frequent than with any other bone of the body. The brachial vessels and nerves are often injured. The musculospiral nerve, which winds about the shaft of the bone, may be injured primarily or later compressed by callus, with wrist-drop. Non-union is favored by the interposition of the fibers of the triceps muscle or by defective immobilization.

Treatment.—When there is little displacement, an internal angular splint or a triangular axillary splint with forearm-rest is used, with narrow short splints or a molded external splint over the humerus.

Jones' humerus-traction-splint and its modifications are designed to give joint fixation, alignment and traction, and are most useful forms of apparatus for fracture of the shaft of the humerus. The associated use of coaptation splints is desirable. In reduction, the normal relation of the external epicondyle to the greater tubercle should be maintained. The action of the retentive apparatus should repeatedly be checked by roentgenograms.

Fig. 134.—Jones' humerus-traction-splint applied.

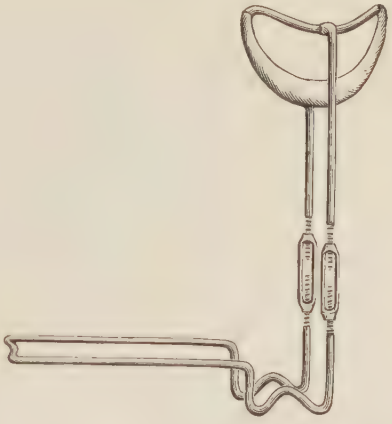


Fig. 135.—Denman-Jones adjustable extension humerus splint.

The position, and traction on the lower fragment should be in the axis of the upper fragment. In severe types the patient should be placed in bed, and a Thomas arm-splint or other traction device used for the first ten to twenty-eight days of treatment. If there is evidence of union in this time, ambulant treatment may be substituted, with the arm fastened to the chest wall, using an axillary internal, angular splint. The support should be continued for five weeks, and the arm protected from undue strain for eight or more weeks from the time of the injury. For delayed union the injection of blood between the fragments, for non-union a sliding bone-graft, is desirable.

Lower extremity of the humerus may be broken: 1. Transversely above the epicondyles—*supracondyloid fracture.*

2. Above and between the epicondyles—T- or Y-*shaped fracture.*
3. *Through either epicondyle.*
4. *Epiphyseal separation.*

Transverse supracondyloid fracture usually results from indirect violence, as a fall upon the hand with the elbow bent; or from direct violence, as from striking the bent elbow. The lower fragment usually slips backward and upward, simulating a dislocation backward of both bones of the forearm. Occasionally the lower fragment passes upward in front of the upper.

Symptoms.—There is swelling, pain, tenderness, loss of function, abnormal mobility, especially rotatory or lateral, with crepitus and deformity, characterized by: (1) Shortening of the arm, measured from the acromion to the external epicondyle, with (2) apparent lengthening or shortening of the forearm, dependent upon whether the lower fragment is carried backward or forward; (3) anteroposterior increase in thickness of the lower end of the humerus, and (4) unaltered relations between the epicondyles and the olecranon.

Diagnosis.—In *dislocation* the normal relation of the three points (olecranon to the epicondyles) is altered, the forearm is shortened, there is no crepitus, and mobility is reduced. Dislocation of the lower end of the humerus causes a

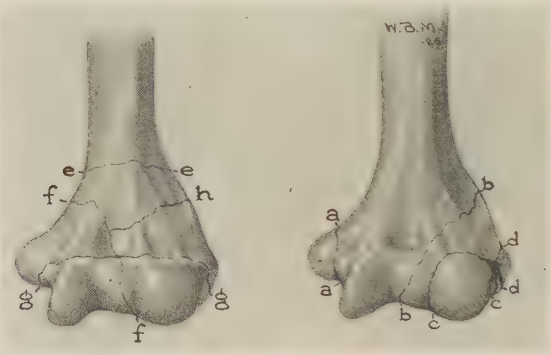


Fig. 136.—Fractures of the lower end of the humerus: *e–e*, Transverse supracondylar fracture; *f–f–h*, Y-fracture; *g–g*, epiphyseal separation; *a–a*, fracture of medial epicondyle; *b–b*, intra-articular fracture; *c–c*, fracture of capitulum; *d–d*, fracture of lateral epicondyle.

smooth projection at or below the fold of the elbow. In *fracture* the lower end of the upper fragment forms a sharp projection above the fold of the elbow.

Reduction of the fracture is easy to bring about, but difficult to maintain, whereas reduction of the dislocation is difficult, but permanent.

Complications include injury to the brachial artery and median nerve.

Intercondyloid fracture consists of a T- or Y-shaped fracture. It is a supracondyloid fracture with an extension into the joint between the epicondyles, and is produced by direct violence.

Symptoms.—Rapid effusion into the joint with widening from separation of the epicondyles, shortening of the humerus, crepitus on moving the epicondyles, pain, tenderness, and abnormal mobility.

Epicondyles of the Humerus.—Fracture of *medial epicondyle* is caused by direct violence, and is partially intracapsular and intra-articular, involving the epicondyle and a part of the trochlea, and, pushed upward by the ulna, may result in *cubitus varus* (*gunstock deformity*). The symptoms are crepitus, abnormal mobility, and effusion into the joint.

Lateral epicondyle is broken by indirect violence from a fall on the hand, or by direct force. It involves the epicondyle, the capitulum and, at times, a part of the trochlear surface, being intracapsular and intra-articular. There is great swelling, ecchymosis, and distention of the joint. On grasping the epicondyle, movement and crepitus are found. Flexion or the rotation of the radius may also give crepitus. There is abnormal abduction or adduction of the extended elbow. Union with *cubitus valgus* is common.

Epicondyles are fractured by direct violence, or by indirect violence with adduction or abduction. The medial epicondyle is more frequently broken, usually by direct violence, by forced abduction of the extended elbow, or muscular action. The fracture is extracapsular, and is usually associated with other injury. Fracture of the lateral epicondyle is intracapsular. As a rule there is little displacement or disability.

Treatment.—Strapping and bandaging in Jones' position for two weeks.

Separation of the lower epiphysis of the humerus is common from direct violence in children between the ages of five and ten years. After fifteen it does not involve the medial condyle. Usually only the capitular portion is separated, the displacement being commonly laterad and backward. The separation may not be apparent on the roentgenogram, and the lesion is easily overlooked, with secondary deformity and arrest of growth of the humerus.

Treatment.—Reduction by flexion and pressure. Fixation by bandage and Jones' position for three weeks.

General Treatment of Fractures About the Elbow.—These fractures are very common in children, and often give marked disability.

Jones' Position.—The arm is fastened in acute flexion to the side of the chest, the affected hand being applied to the opposite clavicle. This position is used for all fractures about the elbow, except fractures of the olecranon. The position is maintained by tying the wrist to the neck by a broad adhesive strap or bandage around the arm and forearm, or by a modified Velpeau bandage. The elbow may be left exposed for local applications and inspection. Jones' position preserves the carrying angle of the elbow, or the normal angle of abduction of the forearm. It reduces the displaced fragments and holds them in place, between the coronoid process and trochlear surface of the ulna in front, and the broad tendon of the triceps behind.

Fixed dressings should not be applied unless (1) Reduction is complete. (2) The carrying angle normal. (3) The radial pulse palpable.

In fractures of the olecranon acute flexion separates the fragments. In T- or Y-fractures of the lower end of the humerus, the coronoid may wedge the fragments apart and, in fractures involving the ulnar groove, the nerve may slip into the line of fracture. If there is marked swelling, the position of acute flexion may cut off the circulation and lead to degeneration of muscles or other structures (*Volkmann's contracture*). With marked swelling or if the flexed position arrests the pulse at the wrist, the arm should be treated during the first one or two weeks in extension with the elbow straight, and then placed in flexion.

Lund swathe is used to comfortably hold the forearm in hyperflexion. A 60 cm. wide and 180 cm. long piece of muslin is folded lengthwise four times, producing a strip 15 cm. wide and 180 cm. long. Beginning over the dorsal spine the

bandage passes over the shoulder on the side of the injury, encircling the flexed forearm and arm, and then passes horizontally around the chest to be pinned in position (see page 529).

Any fracture about the elbow may be followed by limitation of motion, or ankylosis, and the flexed position is that of greatest usefulness. Massage should be started at the end of the first week, fixation continued for three weeks, and support by sling or bandage for two weeks longer. With fractures about the elbow it is important to maintain the normal carrying angle and, if ankylosis is evident, to select the angle of flexion for optimum function. If after one or two weeks of treatment it is found that there is marked displacement, an open operation with reduction and, at times, pegging of the fragments is to be considered. Prolonged fixation without massage is followed by muscular atrophy and fibrosis, fixation of the joint, and prolonged or even permanent disability.

After injury to an important nerve of the arm, one or two years may elapse without return of function, or the paralysis may be permanent. If there is no evidence of improvement from the nerve injury in four months, the nerve should be exposed, freed from callus and adhesions, or treated by hersage or other measure as may be found desirable.

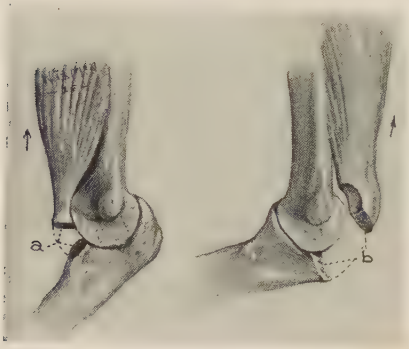


Fig. 137.—Fractures of the elbow from muscular action: *a*, of the coronoid process; *b*, of the olecranon.

Ulna.—The ulna may be fractured through the olecranon, the coronoid process, the shaft, or the styloid process.

Olecranon is usually broken by indirect violence and muscular action in a fall on the outstretched semiflexed forearm or hand. It is also fractured directly through falls or blows upon the flexed elbow.

Symptoms.—(1) The olecranon is movable and drawn upward and backward by the triceps; or (2) if the fibrous expansion of the triceps over the olecranon is not divided, there is no separation of the fragments. In the first case there is effusion into the joint, inability to extend the forearm, and, if the fragment can be drawn down, crepitus.

Complications include forward dislocation of the forearm at the elbow, injury of the ulnar nerve, separation, and fibrous union.

Treatment.—If there is marked separation, an open operation with wiring or suture is the best treatment; or a molded plaster case applied with the forearm extended, or a padded anterior or internal straight splint from the axilla to the fingers may be used, the upper fragment being pulled down by adhesive plaster and a figure-of-8 bandage. After two weeks the arm is gradually brought into a flexed position. The splints are omitted after four weeks. Massage should be used from the tenth day; full use permitted after five weeks if there has been no displacement, and after eight weeks if there has been displacement. Some degree of ankylosis may follow the fracture. Fibrous union does not necessarily interfere with the usefulness of the elbow. With fracture by direct violence, with

no separation of fragments, the arm may be dressed on a right-angled splint from the first.

Coronoid process is usually broken in association with a backward dislocation of the elbow; the dislocation is accompanied by crepitus, is easily reduced, but readily recurs. The fragment may be felt above its normal position, where it has been drawn by the brachialis.

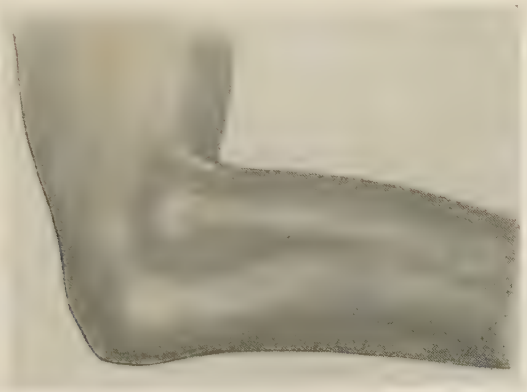


Fig. 138. Fracture through the upper third of the shaft of the radius with anterior dislocation of the head of the radius.

Treatment.—Fixation in acute flexion, as in Jones' position, with a molded posterior splint. Massage and carefully graduated movement should be started by the end of the first week. Functional restoration is usual in five to seven weeks.

Shaft of the ulna is broken by direct violence, and the fracture may be complicated by dislocation or fracture of the radius.

Symptoms.—The lower fragment is pulled toward the radius by the pronator quadratus, the upper fragment slightly forward by the brachialis. There is

Fig. 139.—Fracture through the upper third of the shaft of the ulna with the usual complication of anterior dislocation of the head of the radius. The upper fragment is slightly flexed by the brachialis, the lower fragment pulled toward the radius by the pronator quadratus.

swelling, localized pain, abnormal mobility, depression on the ulnar side, and crepitus, but no shortening unless the radius is broken. Fracture of the upper third of the ulna is often associated with anterior or posterior dislocation of the head of the radius. (This should always be looked for.)

Treatment.—Well-padded anterior and posterior splints, 3 cm. wider than the forearm, the anterior splint reaching from the elbow to the first knuckle,

the posterior splint from the elbow to the wrist. A 2-cm.-wide soft-rubber tubing may be incorporated along the midline of the splints to widen the interosseous space, but should be carefully watched, as it may produce pressure necrosis and ulceration of the skin. The forearm is held in the neutral position between pronation and supination, which gives the greatest width of the interosseous space. After three weeks a molded anterior splint or a straight posterior splint alone is substituted. Union should occur in four weeks.

Styloid process is broken by direct violence, and may complicate a Colles fracture. On grasping the process, it is found to be movable and to give crepitus.

Treatment consists of a pad and strapping over the fractured bone, and the wearing of an anterior molded or Bond splint for three weeks.

Radius.—The radius may be broken through the *head*, *neck*, *shaft*, or *lower extremity*.

Fig. 140.—Comminuted fracture of the shaft of the ulna. (Roentgenogram by Dr. G. C. Bird.)

Head of the Radius.—This fracture occurs chiefly in adults by indirect violence, as a fall upon the palm, or by direct violence, usually as a part of a comminuted fracture of the elbow. There is local tenderness, and the displaced fragments interfere with flexion and rotation of the forearm. These movements may produce crepitus.

Treatment.—Reduction by pressure and acute flexion, if necessary under an anesthetic, with fixation in acute flexion and supination for two weeks, after which the forearm is gradually extended, using massage and gentle passive movements. All retentive appliances are discontinued after five weeks. If malunion or displacement of the bone prevents the desired flexion and rotation of the forearm, excision of the head of the radius is indicated.

Neck of radius is usually broken by indirect violence from falls upon the outstretched hand, the fracture occurring between the head and the bicipital tuberosity; the upper end of the lower fragment may be displaced forward, and supinated by the action of the biceps. There is pain in the region of the neck of the radius: (1) On vertical pressure on the radius; (2) on rotating the forearm,

and (3) in flexing the elbow. On holding the head of the bone it does not rotate and crepitus may be felt on pronating and supinating the hand. The local swelling is not marked, and the fracture is often overlooked.

Treatment.—The forearm should be dressed in acute flexion and supination by an anterior angular splint. Passive movements and massage are started after one week. Restoration requires four to six weeks or longer, dependent

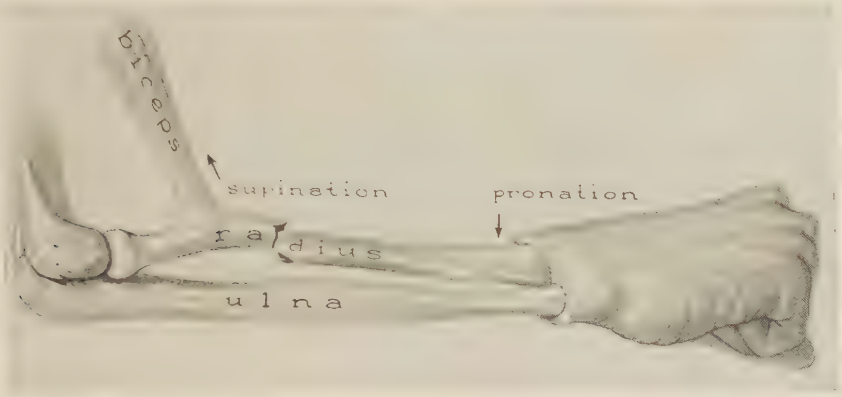


Fig. 141.—Fracture of the shaft of the radius above the pronator teres showing flexion and supination of the proximal fragment by the biceps.

on the degree of laceration of the annular ligament. Malunion, with interference of the movements of the elbow-joint and the rare necrosis of the detached head, requires excision of the head and a part of the neck of the bone.

Shaft of the radius is usually broken by direct violence, but also indirectly through falls upon the hand, fractures of the lower and middle thirds predominating. Greenstick fracture of the radius is common in childhood.

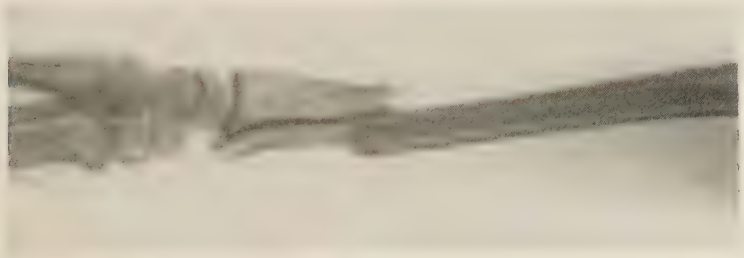


Fig. 142.—Fracture of lower third of radius. (Dr. G. C. Bird.)

1. Above the Insertion of the Pronator Teres: The upper fragment is supinated by the biceps and the supinator, while the lower fragment is pronated and drawn toward the ulna by the pronator teres and quadratus, aided by the brachioradialis.

Symptoms include local swelling, deformity, tenderness, loss of voluntary supination of the forearm, and immobility of the upper fragment when the forearm is rotated at the wrist.

Treatment.—Anterior right-angle splint with the forearm in full supination,

a pad being placed in front of the upper fragment. The splint is worn for three or four weeks.

2. Below the Insertion of the Pronator Teres: The upper fragment is drawn forward and inward by the biceps and pronator teres, into a position between supination and pronation. The lower fragment is drawn into the interosseous space by the pronator quadratus and brachioradialis. Slight shortening, with radial deviation of the hand, is common with fracture of the shaft of the radius

Treatment.—Internal angular splint, with a second short splint for the dorsum of the forearm. The splints should be 3 cm. wider than the forearm, and any radial deviation of the hand corrected. The hand is held midway between pronation and supination for four weeks.

Fig. 143.—Fracture of the lower third of the radius. (Roentgenogram by Dr. G. C. Bird.)

Lower End of the Radius.—1. With Backward Displacement: Colles' Fracture—the second most common fracture.

Etiology.—Falls upon the extended palm. It occurs at all ages, especially in young or elderly adults (old women). The fracture line is nearly transverse, is within $2\frac{1}{2}$ cm. of the articular surface of the radius, and usually is oblique from above downward, forward, and inward.

Deformity.—The lower fragment is displaced upward and backward by the direction of the blow and the position of the limb, and is rotated around the ulnar styloid as a center, so that the outer and dorsal part of the fragment is more displaced than the inner.

Symptoms.—(a) The radial styloid is raised, being on a level with the ulnar styloid instead of below it. (b) The hand is displaced backward, with a bony prominence at a higher level in the front of the wrist (*"silver-fork" deformity*). (c) The hand is abducted, with a prominence of the ulnar styloid. (d) The wrist is tilted backward, the joint surface looking backward and downward. (e) Impaction is usual, preventing crepitus and mobility. The posterior part of the shaft is driven into the lower fragment, and the anterior part of the fragment driven into the shaft. Usually a strip of periosteum on the dorsal surface remains untorn.

Diagnosis is made from a sprain by the relative positions of the styloid processes, and by the peculiar deformity. The hand is pronated, and separated from the forearm by a deep depression on the flexor surface. The distance between the styloid processes is increased, and that between the external condyle and the radial styloid is shortened. At times there is little or no displacement.

Treatment.—Forcible disimpaction is very important, and is usually best carried out under an anesthetic. The upper fragment is fixed by the assist-

ant. The hand is: (1) Hyperextended, to free the fragments and to relax the untorn dorsal periosteum; (2) the lower fragment is then pressed downward by the thumbs, as (3) the wrist is flexed, and adducted into place. Great force and several attempts may be required to accomplish reduction. While, with marked comminution or impaction, it may not be possible to perfectly restore the normal contour, union with the marked deformity and loss of function so frequently seen is inexcusable. After complete reduction there usually is little tendency to displacement. A simple and satisfactory retentive appliance is a posterior straight splint, extending from the elbow to the knuckles, as advocated by John B. Roberts. Good results may also be obtained by the old

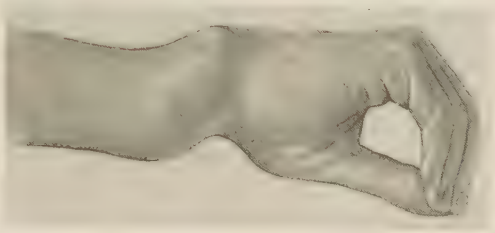


Fig. 144.—Colles' fracture, an impacted fracture of the lower end of the radius with backward displacement and "silver-fork" deformity.

Bond splint, or a molded plaster-of-Paris splint, but the Levis or molded metal splint should not be employed during the first two weeks of treatment.

Cotton-Lodor position of palmar flexion, pronation and ulnar deviation maintained by a plaster case or molded plaster splints, is useful for the difficult type during the first week or ten days, after which the hand should be brought into dorsiflexion. In the elderly and in the rheumatic pain and diminished function frequently follow Colles' fracture. If the bone has united with marked deformity, operative dorsiflexion of the hand, by a wrench or a subcutaneous or open osteotomy, should be considered. Finger movements should be advised

Fig. 145.—Bond's splint.

from the first, with gentle massage and increasing movement of the wrist-joint from the third day, the splint to be continued for three or four weeks.

2. With Forward Displacement: *Smith's fracture* is rather rare, and is produced by indirect violence, through falls upon the back of the flexed wrist or hand. It resembles Colles' fracture, except that there is anterior displacement of the lower fragment instead of posterior, producing "gardener's spade" instead of "silver-fork" deformity. The method of reduction is the reverse of that used for Colles' fracture, the after-treatment being the same.

Chauffeur's fracture is a fracture by direct violence from "back-fire" in cranking a gasoline engine. The starting-handle usually strikes the back of the

lower end of the radius, the hand being adducted. The styloid process is cracked off, and comminution, and involvement of the joint are not unusual. Often the displacement and deformity are slight, and the condition may be mistaken for a severe sprain. This fracture should be treated along the lines described for Colles' fracture.

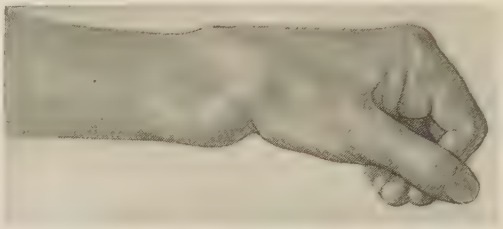


Fig. 146.—Fracture of the posterior articular margin of the radius (Barton's fracture) with deformity suggesting a posterior dislocation of the wrist.

Posterior Articular Margin.—*Barton's fracture* involves the posterior lip of the lower end of the radius, the line of fracture running from behind downward and forward into the wrist-joint, the fragment being triangular. Like Colles' fracture, it is due to indirect violence, from a fall on the outstretched, pronated hand. The displacement may be slight, and the fracture only shown on lateral

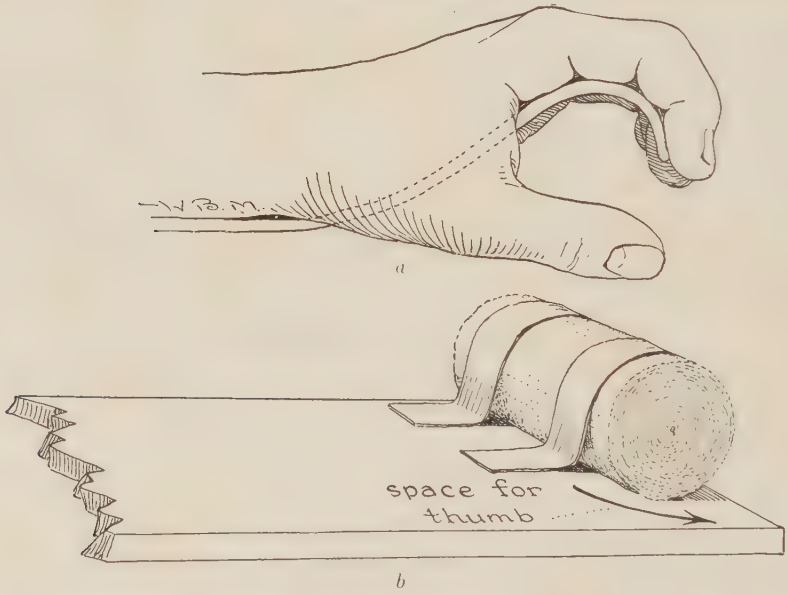


Fig. 147.—*a*, Dorsiflexion or "cock-up" position of hand; *b*, improvised "cock-up" splint, formed of a board and roller bandage.

roentgenograms. Again, the fracture may be mistaken for a posterior luxation at the wrist.

Reduction is easy, but the displacement readily recurs; this should be prevented by treatment in full palmar flexion, adduction, and pronation in a bivalved plaster case, with the fingers and thumb free. After ten days the

hand should gradually be brought into a *cock-up* position, gentle massage and passive movements used, and support continued for a total of three to four weeks. Pain and weakness in flexion of the hand may follow, especially if the fracture has not been well reduced.

Separation of the lower radial epiphysis occurs before the age of twenty, usually in boys between twelve and eighteen years. The epiphysis is displaced backward by indirect violence as in Colles' fracture. There is no impaction, crepitus is soft, and the projection of the lower end of the upper fragment greater than in Colles' fracture. Fracture of the lower end of the radius or separation of the ulnar epiphysis may be associated. Rarely the displacement is anterior and upward, as with Smith's fracture.

The treatment is like that of Colles' fracture. Interference with the growth of the radius and secondary abduction of the hand may follow.

Fracture of both ulna and radius occurs from: (1) *Direct violence*, when both bones fracture at the seat of impact, and at about the same level; (2) *indirect violence*, from falls upon the hand, when the ulna is usually broken at a different level from that of the radius.

Displacement.—The broken ends are usually drawn together by the contraction of the supinators and pronators, with narrowing of the interosseous space. The lower fragments may be displaced laterally or anteroposteriorly,

Fig. 148.—Jones' crab "cock-up" splint for the hand.

often with overriding; angular deformity occurs with greenstick fracture. There is shortening of the forearm, deformity, crepitus, preternatural mobility. The upper fragments may not only be approximated, but supinated.

Treatment.—The fractures are reduced by extension and local manipulation, and the part held between a wide internal angular and a straight posterior splint, in a position midway between pronation and supination. For fractures above the middle third of the forearm a wide anterior angular splint should be used, with a correspondingly wide posterior splint. The anterior splint should extend from the elbow to the distal palmar crease, and should be cut out for the thenar eminence; the posterior splint—from the elbow to the wrist. The splints should be sufficiently wide to avoid lateral compression, a soft-rubber tube may be incorporated in the splint to increase the separation of the interosseous space, carefully guarding the arm from undue pressure and ulceration. The splint should be continued for four weeks, but after the third day it is of advantage to remove the posterior splint daily for massage and inspection. If there is a tendency to bowing toward the ulnar side, the elbow may be extended —using a long, straight anterior splint and a short posterior forearm-splint. For displacement and overriding continuous traction, using a weight and overhead pulley, is valuable. Until reduction is obtained the patient should be recumbent, the elbow being flexed or extended.

Dangers.—*Synostosis* between the ulna and radius may occur, preventing

rotation of the forearm. Ulceration, Volkmann's contracture, and gangrene are produced by tight splints or bandages, or by other interference with the circulation. In fractures of the forearm, poor results are due chiefly to imperfect primary reduction, prolonged immobilization without massage and passive movements, or too early removal of splints; in fractures of both bones, from too narrow or single splints, with secondary synostosis. Much time is saved and many complications avoided by early massage and passive movements. In elderly persons, six months or more are often required before the patient can resume work. Open reduction or operation for non-union is occasionally necessary.

Fig. 149.—The internal angular splint.

Carpal bones are seldom broken, except in crushing injuries with open wounds or in connection with extensive injuries of adjoining parts. The **navicular** (*scaphoid*) is the most frequently fractured single bone. The break usually is caused by (1) a fall on the pronated and extended hand; (2) from a "back-fire" injury, or rarely (3) hyperflexion of the hand. The fracture passes across the middle of the bone (*snapped wrist*) or avulses the tuberosity.

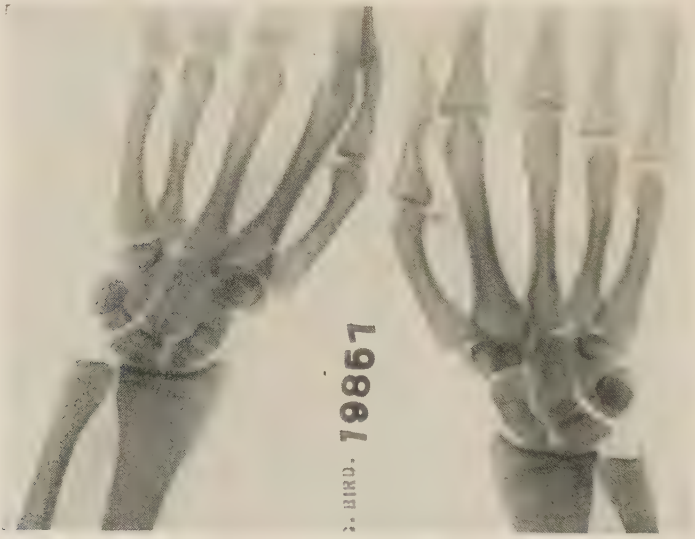


Fig. 150.—Fracture of the left navicular bone. (Roentgenogram by Dr. G. C. Bird.)

Symptoms.—(1) *Soft edema* with tenderness, but without ecchymosis over the *anatomic snuff-box.* (2) *Pain in abduction* and *extension* of the hand, and (3) *localized pain* from an upward thrust on the thumb or index-finger.

Diagnosis.—In a sprain of the wrist the swelling is generalized, and not confined to the region of the anatomic snuff-box. A bipartite navicular should not be mistaken for a fracture on the roentgenogram.

Treatment.—Reduction by extension, manipulation, and pressure, followed by complete immobilization of the fingers, thumb, hand, and forearm on a "cock-up" splint. As non-union is common, massage is used with the limb on

the splint, and fixation continued for four weeks. Laborious work is interdicted for three months. For residual pain and disability, the bone should be excised. Perfect restoration of function after excision is not to be expected.

Lunate (*semilunar*) and **capitate** (*os magnum*) are less frequently fractured alone.

Treatment is similar to that for fracture of the navicular.

Kienboch's Disease of the Lunate Bone.—A destructive osteitis of the semilunar bone with fragmentation, produced by a momentary, spontaneously reduced luxation, with avulsion of the dorsal ligament and tearing of important nutrient vessels. A later injury often occurs, with secondary fragmentation.

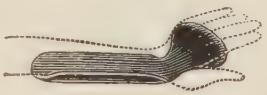


Fig. 151.—Jones' short "cock-up" hand splint.

Symptoms are those of sprain of the wrist, with tenderness, swelling, and disability which often is permanent.

Treatment.—Removal of affected lunate bone, and the wearing of a "cock-up" splint until firm union has occurred.

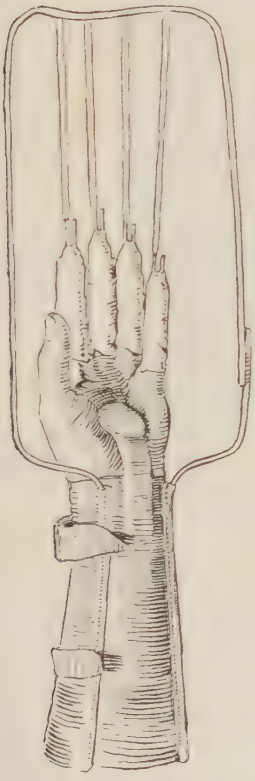


Fig. 152.—Method of producing extension of the fingers by the banjo-splint, using elastic rubber-bands and adhesive plaster.

Base of the First Metacarpal.—*Bennett's fracture* (*stave of the thumb*) is an impacted fracture of the base of the first metacarpal bone, the shaft being driven into the upper fragment. It is produced by a fall or blow on the end of the thumb, or by a blow with the clenched fist. A similar fracture is observed with the fifth metacarpal. Bennett's fracture involves the proximal end of the metacarpal bone of the thumb, including the articular surface. There is posterior angular deformity from the dorsal displacement of the distal fragment, flattening of the knuckle of the affected bone, and swelling and tenderness at the base of the thumb. The pain is increased by movement, and may be associated with crepitus.

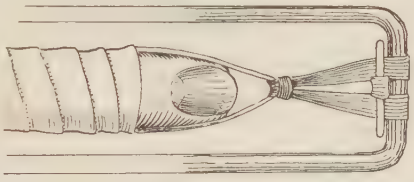


Fig. 153. Method of producing traction upon the thumb or finger by wire, rubber-band, adhesive plaster, and a match-stick. Extension treatment is very valuable in many fractures of the carpal and metacarpal bones.

Treatment.—Reduction is obtained by traction and pressure, under an anesthetic. A dorsal pad is applied over the area of the deformity, and a straight palmar splint used. As the deformity tends to recur, traction of the thumb—by elastic bands, affixed by adhesive strips running to the end of the splint; or by a wire "banjo frame"—is desirable during the first two weeks of the treatment. A splint should be continued for three weeks, massage and passive movements being started during the second week. Imperfect reduction results in restricted abduction of the thumb.

Metacarpal shafts are often broken by indirect violence from a blow with the clenched fist, or by direct crushing violence. In the indirect type there is dorsal bowing, the knuckles being depressed toward the palm with swelling and tenderness.

Fig. 154.—Fracture of the shaft of the proximal phalanx of the third (ring) finger. (Roentgenogram by Dr. G. C. Bird.)

Treatment.—If there is no deformity the fingers are flexed and bandaged around a wrapped roller-bandage for ten to fourteen days. If there is deformity this should be reduced as far as possible by extension and pressure, and the fingers treated by traction on a "banjo" splint or similar device for two weeks. Firm union usually occurs in three weeks. From incomplete reduction there is deformity with incomplete extension, and incomplete flexion of the fingers from impaired action of the lumbricales and interossei. The bones should be refractured by the aid of a wrench or narrow osteotome and a traction splint applied.

Phalanges.—The **proximal phalanges** are most frequently broken, either by direct or indirect violence. Comminution, impaction, splintering, and displacement may or may not be present.

Treatment.—If there is no displacement, a simple finger-splint is used extending to the palm or wrist, or the fingers are bandaged flexed about a roller

bandage. For deformity and displacement elastic traction for ten to fourteen days should be used.

Comminuted fracture of the terminal phalanx of the thumb may have a long period of disability from a hematoma in the pulp of the finger which should be incised and evacuated (Maddren).

Baseball-finger (**drop-** or **mallet-finger**) is an inability to extend the terminal phalanx, from rupture or avulsion of the extensor tendon caused by a blow on the end of the extended finger. The attachment of the long extensor tendon is usually torn off.

Symptoms.—Flexion with loss of extension of the terminal phalanx.

Fig. 155.—Fracture of the neck of the second phalanx with anterior displacement of fragments.

Treatment.—Hyperextension of the terminal phalanx on a molded metal splint for four to six weeks gives excellent results, even in old cases (R. B. Osgood).

The **pelvis** is usually fractured by direct violence from crushing injury or "run-over" accident. The fractures are divided into those involving (a) the false and (b) the true pelvis.

False Pelvis.—Fractures above the pelvic brim involve the crest, sides, and alæ of the ilium and, except for associated visceral injury, are not serious. There is usually little deformity, but local tenderness, swelling, ecchymosis and, at times, mobility and crepitus are present.

Treatment is rest in bed, with adhesive-plaster strapping or a snug pelvic binder. Union requires about four or five weeks.

True Pelvis.—The lines of fracture usually are vertical, through the pubic and ischial rami into the obturator foramen. There may be associated fractures through the sacro-iliac joint of the opposite or the same side.

The double vertical *fracture of Malgaigne* passes through the rami of the pubis and ischium in front, and the corresponding part of the ilium near the synchondrosis behind. Laceration of the bladder, urethra, rectum, uterus, or vagina is often associated. There is little or no external deformity, but the fracture line with slight displacement can often be detected by the finger introduced into the rectum or vagina.

The *symptoms* include *shock*, *pain* increased by movement of the body or legs, by coughing or straining, and *inability to stand* or *sit*. The diagnosis may be difficult because of associated unconsciousness from cerebral injury or other cause. Ecchymosis above Poupart's ligament, or over the sacro-iliac region, with

disability, is suggestive of fracture. The leg is apparently shortened when there is elevation of the detached acetabular portion of the pelvis. Crepitus may occasionally be felt by cautiously moving one side of the pelvis upon the other, or by rocking the side of the pelvis while the finger is in the rectum or vagina. There is local tenderness on pressure, or from upward pressure on the leg. The condition is serious on account of the frequent association of visceral injury.

Rupture of the bladder may be: (1) *Intraperitoneal.*—Usually the fundus of a distended bladder gives way, with the rapid development of secondary peritonitis which is often fatal. (2) *Extraperitoneal.*—Tenderness, swelling, and dulness develop above pubis or in the perineum.

Fig. 156.—Dislocation of symphysis pubis and multiple fractures of pelvis and lower lumbar spine. (Roentgenogram by Dr. G. C. Bird.)

Rupture of urethra: (a) Through posterior layer of the triangular ligament, with rupture of the posterior urethra. The urine extravasates into the cellular tissue about the neck of the bladder, passing to the anterior abdominal wall between the transversalis fascia and the parietal peritoneum. (b) Through the anterior layer of the triangular ligament. The urine infiltrates the anterior part of the perineum, scrotum, penis, groins, and anterior abdominal wall. It is limited by the attachment of the perineal fascia to the base of the triangular ligament, and by the union of the deep layer of the superficial fascia of the abdominal wall to the fascia lata.

Bleeding from the rectum, urethra, or vagina should be investigated, a catheter with funnel attached is introduced into the bladder and, if this viscus is found empty or containing bloody urine, a hydrostatic test for leakage made

with sterile boric acid or salt solution. If the measured quantity of solution entering the bladder does not return, a rupture should be suspected.

Prognosis.—When complicated by visceral injury the prognosis is very serious, especially if operation is delayed. In uncomplicated cases the prognosis is favorable. The average displacement (excluding fracture of the acetabulum) gives no permanent disability; non-union is almost unknown, firm union occurring in six to eight weeks.

Treatment.—With evidence of intra-abdominal leakage or hemorrhage, a prompt exploratory operation should be made, and the opening sutured. With extraperitoneal rupture of the bladder or urethra, the patient is to be prevented from urinating, an indwelling catheter continuously used, or a suprapubic cystostomy made. Free perineal or suprapubic incisions should be made to permit the escape of extravasated urine, pus, and sloughs. For the fracture, the patient should be placed on a firm bed or Bradford frame, the pelvis supported by a belt, a wide strong binder, or adhesive strapping together with lateral sand-bags. The knees should be elevated on a pillow. For displacement, the pelvis is suspended in a broad sling which, by lateral pressure, forces the bones together. An effort should be made to manually correct any marked displacement.

Acetabulum is usually broken by indirect violence, the force being transmitted through the femur.

The **posterior** and **upper lip of the acetabulum** may be broken with a dorsal dislocation of the hip. The dislocation of the hip is easily reduced, but with crepitus and a tendency to recur. The dislocation should be reduced, and fixation with extension in extreme abduction used to prevent recurrence.

Floor of the acetabulum may be fractured by force applied to the great trochanter. The head of the femur is driven into the pelvic cavity, where it can be felt by the finger in the rectum; or the acetabulum may be fractured without displacement of the head. It is more common in the middle aged, the neck of the femur usually giving way in the elderly and in children. This condition simulates a fracture of the neck of the femur, but there is less mobility and shortening. The trochanter is high and deep. After reduction has been obtained—by lateral traction on the upper thigh and abduction, or by combined extension and lateral traction, as with fracture of the neck of the femur—the fracture should be treated by fixation in abduction for six to eight weeks. Reduction may be impossible from fibrous union after two weeks have elapsed. The prognosis after reduction has been obtained is usually good.

Ischium is broken by direct violence, as from a fall in the sitting position. The fracture is comminuted, and may be compound. After the early swelling has subsided, the patient may be permitted to go about in a plaster-spica with the leg extended.

Sacrum may be fractured by direct violence, or indirectly by force transmitted through the spinal column. Comminution or impaction may be present. In a transverse fracture the lower fragment may be carried forward, lacerating the rectum. Deformity, mobility, and crepitus are found on bimanual examination. The sacral plexus may be damaged, with paralysis of the bladder and rectum.

Treatment is reduction by bimanual manipulation and flexion of the thighs, followed by the use of a broad pelvic binder, with a large pad over the upper portion of the sacrum to prevent pressure upon and displacement of the lower fragment. If the bladder is paralyzed, it should be emptied by reflex measures as described under Fractures of the Spine, and without the use of a catheter. The patient should remain in bed for two or three weeks. Union occurs in four or five weeks.

Coccyx is broken by direct violence from a blow, fall or kick, or during childbirth, especially where ankylosis of the sacrococcygeal joint has occurred. The condition, although frequently diagnosed, is rare. There is pain which is increased by walking, sitting, coughing, defecation; by the finger in the rectum, mobility, crepitus, and displacement may be found.

Treatment.—The bone should be replaced by the finger in the rectum, followed by rest in bed for four weeks. Care should be taken to avoid coddling or overtreatment in the neurotic.

Coccygodynia is a painful neuralgic condition referred to the coccyx, and frequently attributed to injury. It occurs chiefly in the neurasthenic or the hysteric, and often no evidence of fracture or deformity is found. Relief is occasionally obtained by injecting a 5 per cent. solution of phenol or a 1 per cent. solution of quinin and urea about the coccyx to block nerve conduction, or by excision of the bone (*coccygectomy*). In a "neurotic patient" the removal of the bone often fails to give relief.

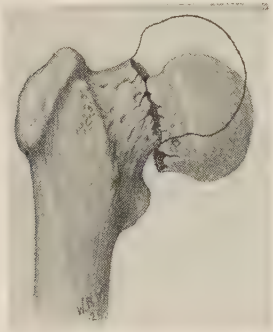


Fig. 157.—Subcapital or intracapsular fracture of the neck of the femur.

Fig. 158.—Fracture at the base of the neck of the femur. (Roentgenogram by Dr. G. C. Bird.)

Neck of Femur.—*Fracture of the small part of neck, central or subcapital fracture, or intracapsular fracture of the femur* usually occurs in persons over sixty, particularly women. In old age the neck of the femur becomes more horizontal, the bony structure partially absorbed and replaced by fat, and osteoarthritis weakens the bone. The fracture results from slight force and indirect violence, such as tripping, catching the toe in the carpet, or turning in bed. A few fibers of the capsule may remain attached to the separated head which,

although cut off from the nutrient vessels of the neck of the bone, receives a little blood-supply through the ligamentum teres. The fracture may be complete, incomplete, or impacted. Impaction is rather rare, but when present drives the neck into the head of the bone. Due to age, insufficient blood-supply, atrophic condition of the fragments, and possibly the action of synovial fluid, non-union or fibrous union is usual.

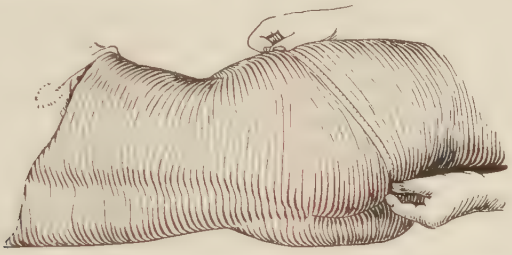


Fig. 159.—Nélaton's line between the anterior-superior spine of the ilium and the tuberosity of the ischium.

Symptoms.—There is helpless eversion, the leg is usually slightly abducted, rotated outward from gravity and the action of the external rotators, drawn upward by the hamstrings and quadriceps. The capsule at first limits any great upward displacement. The head rolls down and back in the acetabulum.

Fig. 160.—Nélaton's line, from the anterior-superior iliac spine to the tuberosity of the ischium, normally crosses the tip of the great trochanter.

The shortening is about 2 to 3 cm.; but after a few days this may increase to 5 cm. or more, from the stretching or laceration of the capsule, and from contraction of muscles. There is relaxation of the femoral fascia and iliotibial band, but some spasm of the muscles anterior to the joint. If the fracture is by indirect violence, local discoloration or bruising does not appear until some days after

the accident. Crepitus should not be produced. With impaction the patient may be able to walk after the injury.

Clinical Tests. - *Nélaton's line* is a line drawn from the anterior superior iliac spine to the most prominent part of the tuberosity of the ischium. The tip of the great trochanter, normally on this line, is above it in fracture of the neck.

Bryant's Triangle.—With the patient on his back, a perpendicular line is dropped from the anterior superior iliac spine; a second oblique line connects the anterior spine with the great trochanter; while the third side of the triangle is formed by a vertical line, running from the perpendicular line at a right angle, and joining the great trochanter. Unilateral shortening of this last line indicates an upward displacement of the trochanter, as occurs in fracture of the neck of the femur.

Chiene's Test.—Two strips of lead or tape are carried across the front of the body, the upper over the anterior superior spines, the lower over the great trochanters: Convergence of these lines points to the side of upward displacement of the trochanter.

Finger test is very simple and quite accurate. With the patient supine, the surgeon stands on the left side of the body, and places the base of the right little

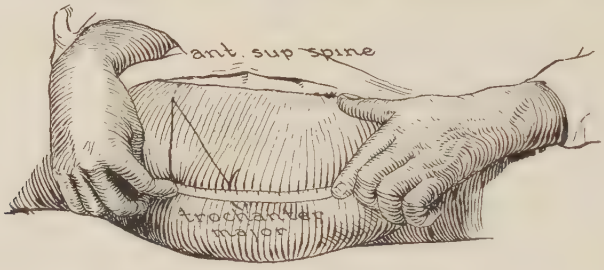


Fig. 161.—Bryant's triangle.

finger on the patient's right anterior-superior iliac spine, the remaining fingers, in apposition, encircle the thigh at right angles to the long axis of the body. The number of fingers between the anterior spine and great trochanter is noted. Standing on the right side of the patient's body, and working with the left hand, the maneuver is repeated. In fracture of the neck of the femur, there will be found reduction of from 1 to 4 fingerbreadths on the affected side.

Ludloff's Sign.—In fracture of the neck of the femur the leg cannot be raised while the patient is lying down.

Prognosis.—In the aged, death occurs in 17 per cent. from intercurrent affections, and bony or firm fibrous union is rather unusual. Defective repair is favored by the poor vascular supply of the head. There is danger from keeping the patient quiet and confined to bed, and difficulty in fixing the fragments in accurate apposition.

Treatment.—The senile or debilitated patient, with intracapsular fracture, poorly withstands confinement in bed and the use of retentive appliances. Hypostatic congestion, pneumonia, and uremia, mental change with delirium, coma, and hemiplegia are not infrequent and may lead to the early death of the patient. To prevent these fatal complications the patient should be propped up

in bed on the first signs of respiratory, cardiac, or mental trouble and, if possible, lifted out into a chair daily. If necessary, the fracture is neglected, so that the life of the patient may be saved. Fixation of the fragments, however, reduces shock and pain.

Abduction treatment (Royal Whitman, 1902) gives the best results. Under anesthesia, complete abduction, hyperextension, and internal rotation is produced, traction being first made until the shortening is overcome. The abduction position prevents shortening, absorption of the neck of the femur, and coxa vara, and gives a fixation favorable to bony or fibrous union. Supported by a plaster case, the patient may be moved about in bed, rolled over, and transferred daily to a wheel-chair.

Methods: 1. Traction until the legs are of equal length.

2. Complete abduction of uninjured leg to fix the pelvis.

3. Preliminary flexion to free fragments.

4. Complete abduction of injured leg, while traction, internal rotation, and slight hyperextension of the hip is continued. Disimpaction should not be done, even for deformity, in a very feeble or elderly person; and, with impaction, the plaster may be applied with the hip in the more comfortable flexed position.

5. Plaster spica from toes to lower thorax, padding all bony prominences with saddler's felt or wadding. Both hips need not be encased provided the plaster covers the lower ribs. The knee is placed in moderate flexion to maintain the internal rotation. Slings, counterweights, and hand-grips facilitate the movements of the patient in bed. The patient usually is placed in a chair, after two or three days, for increasing periods of time.

Fixation is used for at least three months, and support by a walking caliper brace continued for nine months longer. Bony union or strong fibrous union is usual. For painful non-union, which frequently follows faulty reduction and insufficient fixation, a bone-graft, the Bracket operation, or the Whitman operation may be used.

If a case cannot be used, extension may be made in abduction by Buck's apparatus or a Thomas splint, with lateral support by sand-bags. *Maxwell-Ruth method* consists in Buck's extension with a second point of traction from a band around the upper thigh, arranged to cause a lateral pull and internal rotation. The ambulatory abduction-splint of Bradford may also be used.

Buck's Extension.—Broad strips of adhesive plaster, applied to the sides of the limb, extend from the level or above the level of the fracture to a wooden spreader block placed a few centimeters below the heel. The spreader block prevents pressure on the malleoli. Usually a roller bandage is carefully applied over the traction strips of adhesive plaster. From the center of the spreader block a rope passes over a pulley to weights sufficiently heavy to make the desired extension. Counterextension is obtained by gravity, the foot of the bed being raised, by a perineal band fastened to the head of the bed, or by other device. To better immobilize the fractured bone long sand-bags, splints, or a plaster case are used.

In young robust adults absolute reduction should be obtained, if necessary, by an open operation and the insertion of a heavy screw or peg of bone, which extends from the trochanter through the neck, into the head of the bone. The operation is followed by the usual treatment in abduction.

In all cases great attention should be paid to the general physical condition. Massage and daily baths should be given, the patient's position frequently changed. Pressure or bed-sores may form in two or three days, become very deep and difficult to heal, and cause a fatal toxemia.

Fracture of the neck of the femur in children and infants is rather common and often overlooked. It results from a fall or forcible twist of the thigh. The fracture may be complete and impacted, or of the greenstick variety. Usually the patient is able to walk with a limp, there is slight eversion, shortening of 1 to 2 cm., and the movements of the hip are restricted and painful. This fracture is a common cause of coxa vara.

Treatment.—Even though the fracture is incomplete or impacted, the deformity should be fully corrected, and the limb put up in plaster of Paris in wide abduction. The diagnosis and correction should always be confirmed by a roentgenogram.

Ununited fracture of the neck of the femur is associated with an upward displacement of the trochanter of from 3 to 7 cm., with adduction of the shaft of the femur.

Treatment.—1. *Bone-graft* to aid bony union is applicable in about one-fifth of the cases, and gives variable results. It is to be avoided where there is marked atrophy of the head and absorption of the neck of the femur.

If there is much shortening, and the patient's general economic condition requires a rapid convalescence and a stable hip, one of the following operations is preferable:

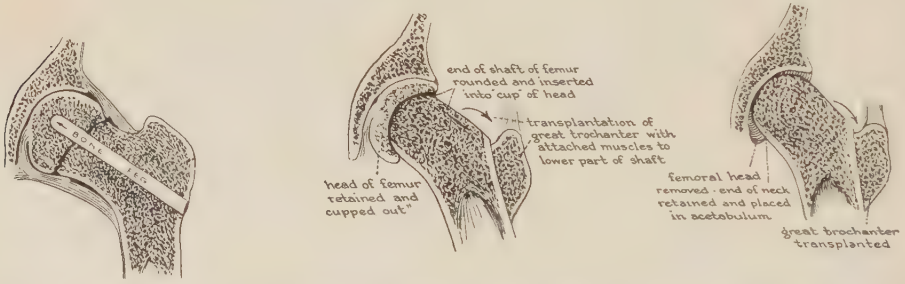

end of shaft of femur rounded and inserted into cup of head
transplantation of great trochanter with attached muscles to lower part of shaft
head of femur retained and cupped out
femoral head removed - end of neck retained and placed in acetabulum
great trochanter transplanted

Fig. 162.—The bone-graft, the Bracket operation, and the Whitman operation used for painful ununited fractures of the neck of the femur.

2. *Lorenz bifurcation operation* consists of (a) osteotomy of the femur below the trochanter; (b) displacement of the lower fragment inward and upward, so that the upper extremity of the shaft rests against the remainder of the head and acetabulum. This operation may be rapidly performed through a short incision, gives fair stability, a shortening of 2 or 3 cm., and can be employed for patients who are such poor operative risks that an extensive operation would be hazardous.

3. *Bracket's Operation* (1917).—The head of femur is reamed out, leaving a shell of articular cartilage, against which the rounded end of the shaft is placed in wide abduction. The great trochanter is cut off and reattached at a lower point on the shaft. The shaft may be levered out of the new socket by adduction, or the shell of the head remaining may (rarely) act as a foreign body and cause arthritic symptoms. The operation is less satisfactory than that of Whitman.

4. *Albee's Operation.*—(a) The head of femur is removed. (b) The great trochanter, with its muscular attachments, and outer portion of the shaft of the femur are chiseled off and pried outward, forming a bone lever 12 cm. long. (c) The remains of the neck and trochanter are rounded and placed within the acetabulum, and the thigh abducted. The upper end of the lever impinges against the lateral surface of the ilium, preventing displacement.

5. *Whitman's Operation* (1921).—(a) The femoral head is removed. (b) The outer portion of the trochanter is chiseled away with its muscular attachments. (c) The remains of neck and trochanter

are reshaped, and inserted into the acetabulum. (d) The leg is abducted, and detached portion of the trochanter is transplanted to a lower level on the shaft of the femur. The operation gives excellent results.

Separation of capital epiphysis occurs about the time of puberty, especially in boys, from stumbling or tripping with the leg hyperextended, the taut Y-ligament serving as a fulcrum.

The **displacement** may be: (a) *Partial*, with slight persistent limp, slight shortening, limitation of abduction and internal rotation, excessive external rotation, and a Roentgen-ray outline of coxa vara. (b) *Complete*, resembling fracture of the neck of the femur, with shortening and eversion of limb. The diagnosis is made by the roentgenogram.

Etiology. "Adolescent rickets" which occurs with rapid growth, endocrine or nutritional disturbance, and is associated with weakness of the epiphysis.

Prognosis.—Permanent lameness, with the leg in adduction and external rotation, follows lack of treatment.

Treatment.—Reduction by abduction, extension, and internal rotation, the position being maintained by flexing the knee and applying a plaster spica from the toes to the lower thorax. After eight weeks a *Bradford abduction caliper-splint* may be substituted. In certain cases of complete separation *open reduction* (Smith-Peterson incision) is desirable.

Fig. 163.—Pertrochanteric fracture of the femur.

Fracture of the Base of the Neck, Fracture of the Large Part of the Neck, Extracapsular Fracture.—The line of fracture is usually partly within and partly without the capsule.

Special Varieties.—1. *Intertrochanteric fracture* follows the anterior oblique line connecting the trochanters. It occurs chiefly in the aged and usually is impacted, with slight displacement of the fragments and a coxa vara type of deformity. Early bony union is usual and, if impacted, a Thomas splint gives sufficient support. If not impacted, the Whitman abduction treatment should be used. The neck may be driven as a wedge between the trochanters, splitting them off.

2. *Pertrochanteric fracture* is rather rare, and passes through the base of the neck or upper end of shaft, distal to the great trochanter and usually proximal to the lesser trochanter. Comminution may occur with detachment of the lesser trochanter. The treatment, which should include accurate reduction, is similar to that for intertrochanteric fracture.

3. The neck is driven into the great trochanter, the joint usually being involved anteriorly, although the fracture is extracapsular posteriorly.

Etiology.—Fractures of the large part of the neck usually are due to great violence applied directly to the great trochanter. The break usually occurs in robust adult men, rarely in the aged. Occasionally the fracture follows indirect violence from a fall upon the feet or knees.

Symptoms.—From the severe injury there is usually shock, local bruising, and severe pain. The leg lies in helpless eversion, with a shortening of 3 to 5

cm. The vertical side of Bryant's triangle is shortened, and the trochanter is nearer the midline than normal. *The Bitrochanteric Test:* The trochanteric region is thickened, the iliotibial band relaxed, the trochanter rotates around the arc of a smaller circle than normal, and there is crepitus unless impaction is present. In a small percentage the distal fragment is in front of the proximal with inversion of the limb. On palpating the lateral part of Scarpa's triangle a tender firm mass of bony fragments may be found. If *impacted*, the shortening seldom exceeds 2.5 cm., the eversion is less; there is some power of voluntary movement and no crepitus; the thickening of the trochanteric region is greater, and the great trochanter approximates the acetabulum.

Fig. 164.—Fracture of neck of femur. (Roentgenogram by Dr. G. C. Bird.)

Diagnosis.—Chronic osteo-arthritis may be associated with crepitus, shortening, and bony deformity. The condition, however, is chronic and progressive, and associated with bony changes in other parts of the body.

Dislocation occurs in young adults from indirect violence, the force being applied to the knee, foot, or back, with the thigh flexed. Deformity and restricted movement are characteristic of the different dislocations, and the head of the bone may be felt in its new location. The possibility of associated dislocation with fracture of the rim of the acetabulum should be remembered.

Morbus coxa occurs in the young, with flexion, adduction, and internal rotation, but without change in the normal measurements.

Prognosis.—There is little danger to life except in the aged, but shortening and limitation in movements of the limb frequently follow. Movements are impeded by the shortening and depression of the neck of the femur, and excessive callus formation which is usual. Permanent eversion or, where the distal fragment lies in front of the proximal, permanent inversion is common.

Treatment.—In young and healthy patients the fracture should be disimpacted under an anesthetic, the shortening, eversion, or inversion corrected, and the thigh put up in marked abduction and flexion with a well-fitting plaster-of-Paris spica for six to eight weeks, after which the patient may go about on crutches with a walking-caliper, but should avoid early weight bearing.

Separation of the upper epiphysis usually occurs about the age of fourteen, the head not joining the shaft until the age of eighteen. The separation is produced by falls upon the leg or hip, and gives rather vague symptoms with incomplete disability, somewhat like those of an intracapsular fracture but less marked, and, if not treated, the condition results in marked coxa vara. The crepitus is muffled.

Treatment consists in fixation of the hip in a position of marked adduction for six to eight weeks, followed by a walking-caliper and crutches until six months have elapsed.

Separation of the great trochanter usually follows direct violence, but may occur from muscular action. If from muscular action, the trochanter is displaced by the gluteal muscles upward and backward, unless the fibrous attachments are not fully severed. As a rule there is little displacement. In young persons the epiphysis of the great trochanter may rarely be separated.

Treatment.—If there is displacement, the fragment is best fastened in position through an open operation, by sutures of chromic catgut or kangaroo tendon, by screws or pegs of bone or ivory. In other cases a pad may be strapped over the fragment, and the thigh placed in a position of adduction in a case or other appliance for four weeks.

Fractures of the lesser trochanter are very rare, but occur in the young from muscular contraction of the psoas while the thighs are spread. The break may follow direct violence.

The **symptoms** include ecchymosis along the inner surface of the thigh, pain and tenderness in Scarpa's triangle (2 or 3 inches below the groin), with external rotation of the thigh. By lying down the patient is able to raise the heel from the bed by the rectus and the quadriceps extensor group. When sitting the leg cannot be raised, as the rectus is relaxed and the psoas inoperative.

Treatment consists in fixation of the thigh in flexion with internal rotation for four weeks; this position relaxes the detached psoas.

In *compound fracture about the hip* the abduction traction-splint of Crile is useful.

Shaft of the Femur.—Fractures of the shaft of the femur occur in the upper, middle, and lower third, and are transverse, oblique, or spiral. Fractures of the upper third are uncommon and usually due to direct violence; of the middle third most frequent, and due to direct or indirect violence or, rarely, muscular action; while those of the lower third result from direct violence. As a rule there is marked deformity and displacement, with injury of the soft parts and, occasionally, of the vessels or nerves. Robust men between eighteen and forty years of age and children under ten years are most frequently affected.

Deformity.—In the *upper third*, the proximal fragment is flexed by the psoas, rotated outward, and tilted laterally by the external rotators, the lower

fragment being pulled upward by the flexors and extensors, inward by the adductors, and rolled outward by the weight of the leg. In the *middle third* there is a tendency to a backward sagging and loss of the normal anterolateral convexity. The distal fragment is pulled inward and posterior to the proximal by the adductors. In the *lower third* the gastrocnemius draws the lower fragment backward, endangering the popliteal vessels, the upper fragment often being driven down into the quadriceps muscle, the knee-joint, or the skin.

The **diagnosis** is easily made from the shortening (from 1 to 10 cm.), angulation, deformity, mobility, and crepitus. Mobility and crepitus may be shown by gently lifting the limb, with the hand placed under the point of fracture. The trochanter does not follow gentle rotatory movements of the leg. Shock is frequently present.

Lower End of the Femur.—1. *Transverse fracture* resembles that of the lower third of the shaft, with a similar tendency to a backward tilting of the lower fragment by the gastrocnemius, with possible injury of the popliteal vessels.

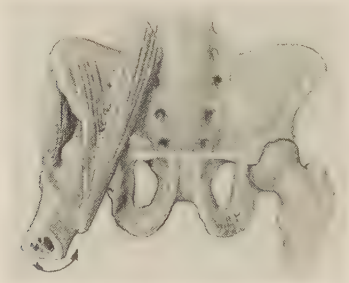


Fig. 165.—Fracture of the upper third of the femur; the upper fragment is flexed by the psoas and rotated outward and tilted laterally by the external rotators.

Fig. 166.—Fracture of the lower part of the shaft of the femur, showing flexion of the distal fragment produced by the gastrocnemius and the jeopardy of the popliteal vessels.

2. T-*shaped fracture* into the knee-joint occurs.

3. *Separation of one condyle* is rare, and is characterized by crepitus on pressing or moving the condyle, and by marked effusion into the joint.

4. *Separation of the Lower Epiphysis.*—The epiphysis is displaced forward, and the lower end of the shaft presses on the popliteal vessels.

Fractures of the shaft of the femur are major injuries, frequently followed by great shortening and deformity from lack of care in treatment. Injury to important vessels or nerves often is associated. The gunshot fractures of the femur in the war gave a mortality of 50 per cent.

Treatment should: 1. Overcome (a) *shortening;* (b) *angulation;* (c) *rotation.*

2. Restore the *normal anterior bowing of the femur.*

3. Take care of associated injury to *vessels*, *nerves*, or the *knee-joint.* Strong extension, to overcome the contraction of the powerful muscles of the thigh, is necessary in the treatment of nearly every fracture of the shaft of the femur. The leg should be restored to its full length, traction being made in the axis of the upper fragment in correct alignment. External or internal rotation of the lower fragment must not be permitted, and traction should not be made through the knee-joint. *Pointed toe*, or plantar flexion of the foot, should be prevented

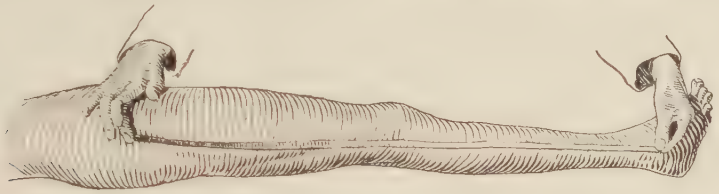


Fig. 167.—Measurement of the leg from the great trochanter to the external malleolus.

by supporting the foot. The Thomas splint may be used in nearly all cases, and gives excellent results. The Thomas splint should be slung from an overhead frame, additional traction may be made through weight and pulley, with the end of the splint, giving *sliding traction.* Skin traction is applied to a point well above the line of fracture. The crest of the tibia and the supramalleolar zone should be padded. Sufficient traction to overcome all shortening is continued for six or eight weeks, when it is replaced by a walking-caliper or plaster case. For *fixed traction* one extension cord is carried about the lateral

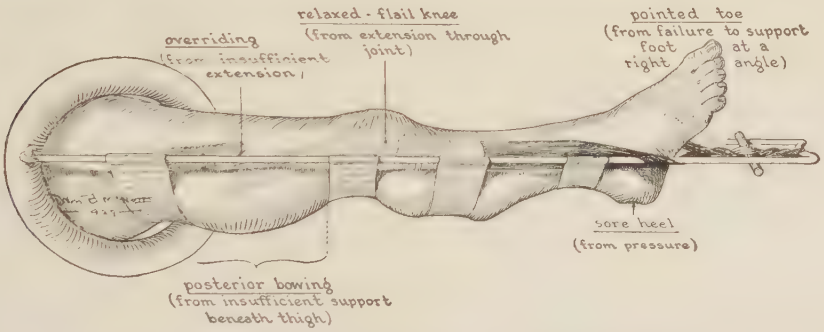


Fig. 168.—Common errors in the treatment of the fractures of the shaft of the femur causing prolonged or permanent disability.

rod of the Thomas splint from without in, the other about the mesial rod from within out. The ends are firmly tied over the end of the splint. Additional traction is now made by twisting the cords below the foot by a short strong rod. This tension should be adjusted daily. When sufficient external extension cannot be made to correct the deformity, a direct pull upon the lower fragment should be made by the use of a transfixion pin or "ice tongs" in the condyles.

Upper Third: The leg should be in wide abduction, slight external rotation,

and at an angle of about 40 degrees to be in the axis of the upper fragment. Skin traction is usually sufficient to overcome deformity.

Middle Third: Skin traction, as a rule, suffices. The femur should be sufficiently supported to maintain the normal anterior curve of the femur. Lateral traction—bands or pressure pads may be necessary to overcome lateral displacement.

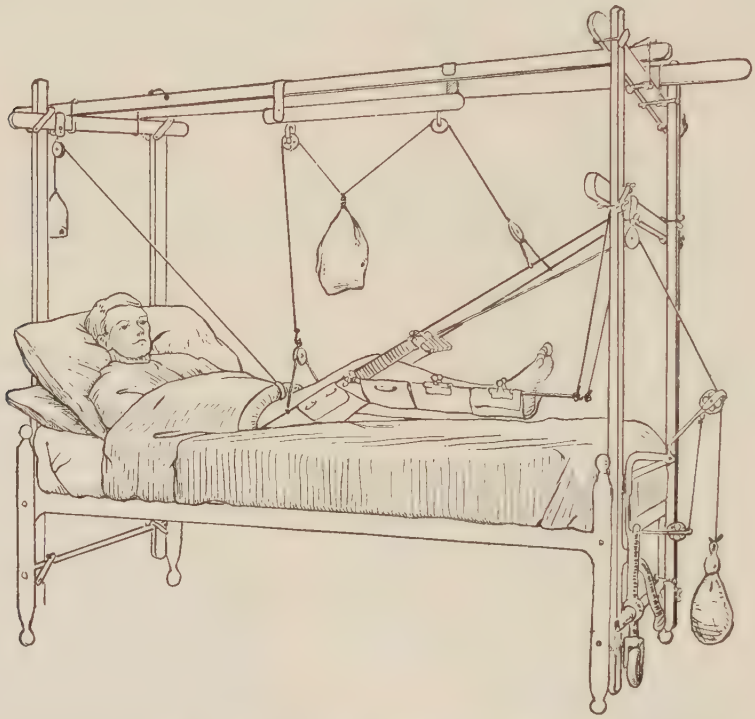


Fig. 169.—Balkan frame with suspended knee-bent Thomas splint and sliding traction applied for fracture of the lower third of the right femur.

Lower Third: Flexion of the knee to relax the gastrocnemius is necessary in most cases, as is skeletal traction by calipers to overcome the shortening.

The asepticized skin is pulled up and lateral incisions made to the bone, crossing the axis of the bone on a line just above the adductor tubercle. The calipers are now inserted into the outer layers of the bone, wrapped with gauze moistened with compound tincture of benzoin, the dressing completed, and extension immediately applied. A lock-nut is adjusted to prevent undue penetration of the bone. The calipers are removed in six weeks, or earlier if there is pain, displacement, or infection.

For *supracondylar* and *comminuted fractures* the calipers are unsafe, as they may slip into the joint. If skeletal traction is necessary the Steinmann pin may be used.

An initial traction force of 12 to 20 kilos is applied to the skin, or 10 to 15 kilos to the bone.

Distraction is avoided by reducing the weight as soon as all shortening has been overcome. All apparatus should be inspected and adjusted daily.

Duration of Treatment.—Retention should be continued for eight to twelve weeks, the patient using crutches for three or four weeks longer. Following the rule of Nélaton, the treatment should last 100 days, but for eight or ten weeks longer a caliper-splint or other support should be worn to prevent bowing, angulation, or refracture. The callus should be firm, free from tenderness, and sufficient bony union should be evident on the roentgenogram. The average duration of the disability is nine and a half months. It is to be remembered that the union will be slower and less firm when a Lane plate or similar contrivance is used. For transport, Liston's splint or, better, Thomas' splint may be used. A satisfactory result consists of good alignment, with shortening not over 2 cm.

Fracture of Femur in Children.—Fracture of the femur is common in children under the age of ten, and often is incomplete or of the greenstick variety.

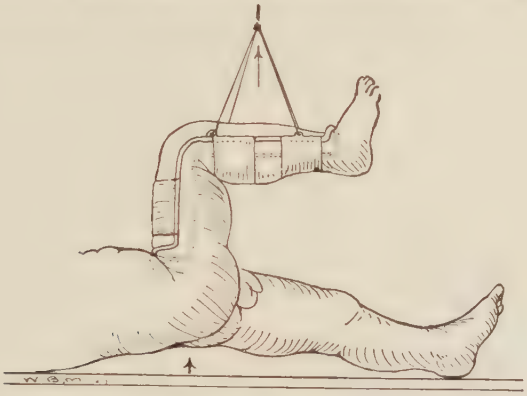


Fig. 170.—Extension in the knee-flexed position for fracture of the lower third of the femur in a child; counterextension is produced by the weight of the body.

In young children, vertical extension of the injured or of both extremities, with or without flexion of the knee, is very valuable. Skeletal traction may damage the epiphysis, and is rarely indicated. The patient may be allowed out of bed after four weeks, using plaster or other retentive appliance for four weeks longer.

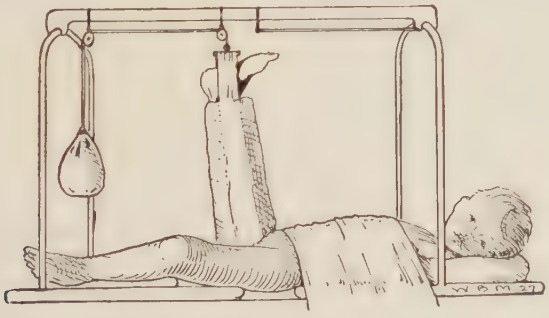


Fig. 171.—Method of support and vertical extension for fracture of the femur in a child.

Congenital fractures occasionally occur from efforts at delivery, especially in a breech presentation. Extension with a Thomas knee-splint may be used for this fracture.

Comment.—Fractures of the shaft of the bone in children usually give good results, with early union. Fracture of the shaft in adults, with rotation or angular deformity, gives fair results after six to twelve months. More or less permanent disability for hard work follows fractures of the neck of the femur, or those involving the knee-joint, as well as fractures with marked malunion; for the latter, operation with bone-grafting is frequently desirable. Open operation affords accurate reduction, but does not insure fixation, and is followed by slower return to full function than an equally accurate closed method. Metal plates, screws, wires, bands of Parham, or intermedullary pegs reduce osteogenesis and frequently become displaced, broken, detached, or cause late irritation necessitating removal. It is essential that as careful external support be given after their use as though no internal fixation were used.

Supracondylar and T-shaped fractures of the lower end of the femur are very serious, and usually occur in adult males from a fall on the feet or knees or from direct violence. There is marked swelling with great effusion into the

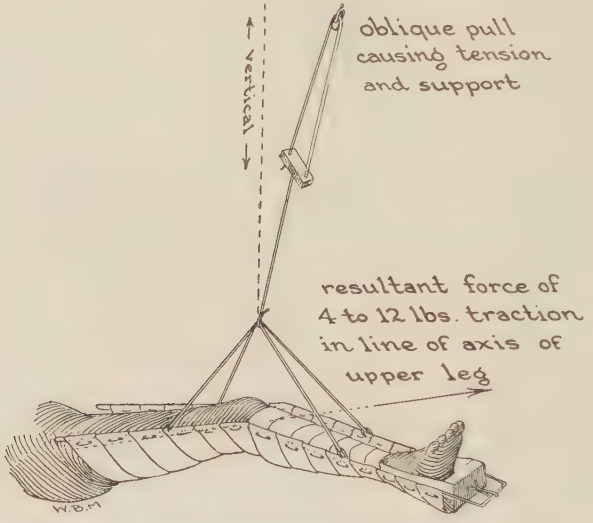


Fig. 172.—Showing the manner in which traction is produced by the Hodgen splint. Adhesive plaster for skin traction is applied as for a Buck extension.

knee-joint; the lower end of the upper fragment projects anteriorly, the upper end of the lower fragment being tilted into the popliteal space. The popliteal vessels may be lacerated at the time of injury, or later, or so pressed upon that gangrene follows if reduction is not soon obtained.

Treatment.—A Thomas knee-bent splint with a flexion attachment, bent to an angle of 30 degrees so that there is flexion both at the knee and hip, is usually necessary to maintain reduction. For extension, skeletal traction by Steinmann pin is desirable. Hodgen's splint, bent to nearly a right angle, affords the necessary flexion and some degree of traction. It may be necessary to nail a broken condyle to maintain it in position.

Lower femoral epiphysis is partially or completely separated—especially in boys between the ages of eight and fourteen—from rotation and hyperextension

of the knee. The injury often results from the leg slipping between the spokes of a moving wheel (*cart-wheel fracture*). In complete separation the ends slip downward and backward into the popliteal space, the epiphyseal end lying anterior and being tilted upward by traction of the gastrocnemius. The separation, as a rule, is extra-articular. There is shortening and abnormal mobility, with a mass from the lower end of the diaphysis lying in the popliteal space, the up-tilted articular surface being in front.

Treatment.—Reduction under anesthesia is made by pressure and counter-pressure, as traction is made with the knee flexed. A case from the groin to the toes is applied with the knee in flexion, the knee being straightened, and another case applied after four weeks. Weight bearing may begin at five weeks, and all support discontinued at the end of eight weeks.

Patella is often broken by direct violence or muscular action. The injury occurs between the ages of twenty and fifty years. Direct violence causes a stellate or fissured fracture, without separation of the aponeurosis and with little or no displacement of fragments. In muscular action, as with a missed kick, the contraction of the quadriceps extensor snaps the patella over the femoral condyles, much as a stick is broken over the knee. The fracture is transverse, and the aponeurosis and lateral expansions of the patellar tendon are torn and adhere to and partially cover the rough fractured bone ends. The fracture is transverse, with a separation of from 1 to 8 cm. Hemorrhage and effusion occur into the knee-joint.

Fig. 173.—Stellate fracture of the patella from direct violence. As the patellar ligament is not ruptured there is no separation of fragments.

Fig. 174.—Showing early stage of transverse fracture of the patella by indirect violence.

Symptoms.—In the transverse fracture the patient is unable to extend the knee, and there is a gap between the upper and lower fragments of the patella, with effusion in the knee-joint. In the stellate or comminuted fractures the patella is tender, boggy, and may give crepitus. Voluntary extension of the leg may be possible, but painful.

Treatment.—For *transverse fracture* with separation: Rest in bed, support with the knee straight, together with fomentations or evaporating lotions, are used for the first seven to ten days, or until the tissues have partially recovered from the primary traumatism. A vertical or transverse incision is then made

over the patella, the blood-clot evacuated from the joint; the torn adherent portions of aponeurosis separated from the fractured surfaces, which are accurately apposed, and held by suturing the torn lateral expansions of the patellar ligament with strong chromic catgut or kangaroo tendon. The edges of the torn aponeurosis in front of the patella may also be united by fine chromic-catgut sutures, and the wound closed accurately without drainage. A plaster case from the groin to the toes is applied, bivalved, and the leg elevated. Massage is started at the end of the first week, light passive movements at the end of three weeks, and limited weight bearing after six weeks; all appliances being removed after eight weeks. The non-operative treatment includes adhesive-plaster strapping of the patella, with the knee extended and the leg elevated. Support with gradually increased movement is used for six months.

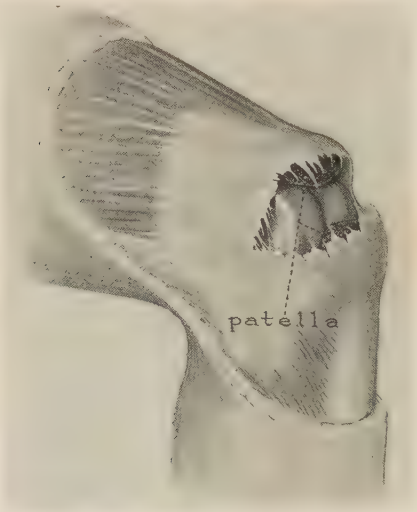


Fig. 175.—Transverse fracture of patella showing involvement of knee-joint and laceration of lateral expansions of the patellar ligament.

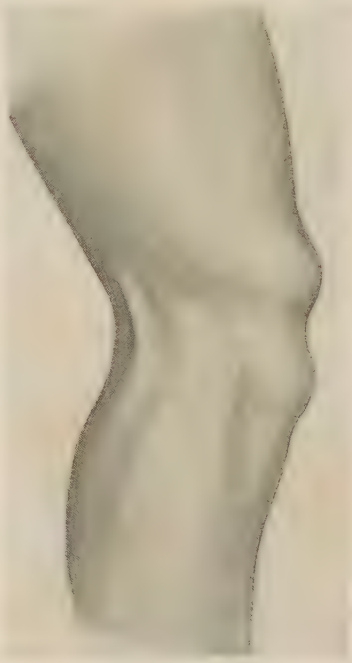


Fig. 176.—Deformity from transverse fracture of the patella.

Closed methods of treating transverse fractures of the patella fail because the fibrous tissue covering the broken ends of the bone is not removed, and fibrous union, separation of the fragments, and more or less permanent disability from the weakness in extending the leg follows.

For the *comminuted fracture* without separation of fragments a padded posterior splint, or plaster-of-Paris or silicate case, should be worn for from four to six weeks. For persistent effusion into the knee-joint aspiration may be used. Where facilities for dependable aseptic surgery are not at hand, transverse fractures of the patella with separation should be treated by a posterior splint, with adhesive-plaster strapping and bandaging to hold the parts in as close apposition as possible. The securing of apposition of the fragments by

the encircling subcutaneous ligature of Barker or Roberts is followed by only fibrous union.

Fig. 177.—Transverse fracture of patella with separation of fragments. (Roentgenogram of Dr. G. C. Bird.)

Prognosis.—Refracture or separation occurs in about 15 per cent. of the patients, especially in those not treated by an open operation.

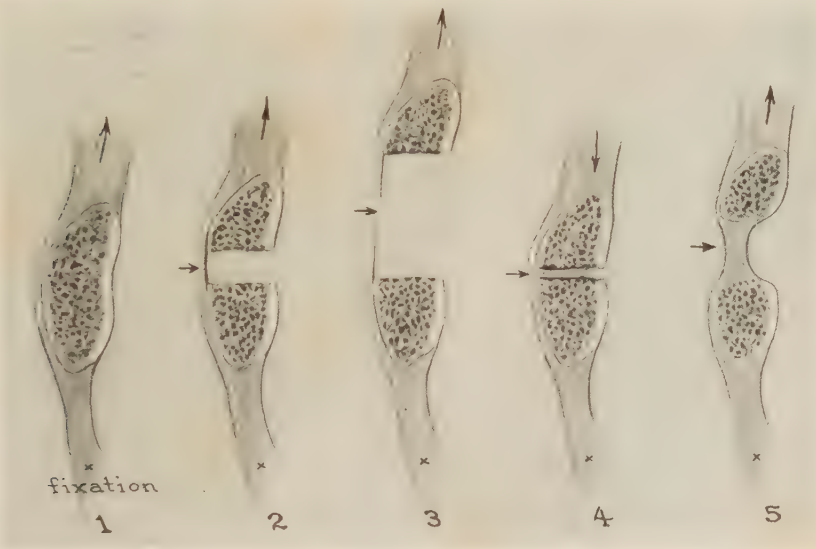


Fig. 178.—Transverse fracture of the patella: 1. Normal lines of force. 2. Transverse fracture with rupture of the anterior expansion of the patellar tendon. 3. Frayed out and torn patellar ligament. 4. Bone fragments separated by the adherent torn prolongations of the patellar tendon which prevent bony union. 5. Separation of fragments after fibrous union from stretching of the fibrous tissue. The surfaces of fracture must be cleared of fibrous tissue to enable bony union to occur.

Fractures of the Tibia.—These fracture involve the upper end, the tubercle, the shaft, or the medial malleolus. *Fractures of the upper end* usually result from direct violence, or indirectly from a fall upon the feet. The line of fracture may be transverse or oblique, and the distal fragment impacted

into the proximal with comminution. From *oblique fracture of either condyle* union with displacement may occur, resulting in genu varum or valgum. A condyle may be broken by forced adduction or abduction at the knee. Marked effusion and swelling follow if the line of the fracture enters the joint. A T-fracture of the head also occurs. Separation of the upper epiphysis of the tibia is rare and usually is found between the ages of three and nine. The epiphysis is displaced forward or laterally. Shortening or angular deformity may later develop from interference with the growth of the limb. After reduction there is, as a rule, little tendency to displacement, and a straight or angular posterior molded splint should be worn for five or six weeks.

Treatment.—Fractures of the head of the tibia should be reduced under an anesthetic and, if the head is comminuted or split obliquely, traction by adhesive strapping and fixation used. At times ice-tong calipers, grasping the malleoli or the calcaneus, may be necessary to prevent displacement of the fragments. A Thomas splint may be used or, if there is little tendency to displacement, a MacIntyre splint or plaster case. An open operation (with the insertion of pins, nails, or bolts) is often desirable when complete reduction cannot otherwise be obtained. Passive movements of the knee are started on the third day.

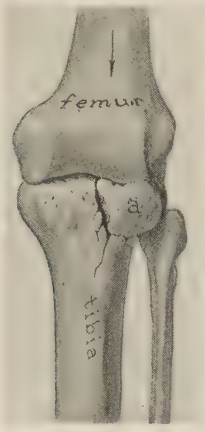


Fig. 179.—Intra-articular fracture of the lateral condyle of the tibia—the downward displacement of fragment *a* causes genu valgum.

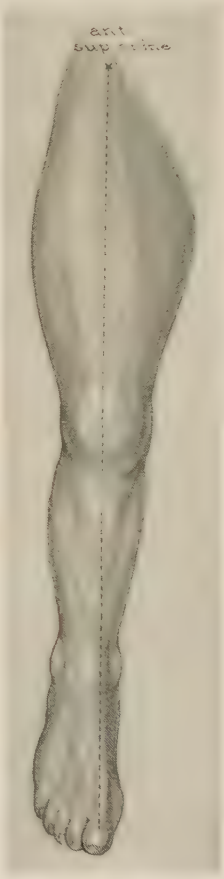


Fig. 180.—Normally a line from the anterior superior spine to the great toe crosses the middle of the patella. After reduction of a fracture of the leg the parts should have this relationship.

Tuberosity generally grows down as a beak-like process from the head of the tibia, or it may ossify from a separate nucleus which appears about the

age of twelve, and joins the shaft at fourteen. In the young the tuberosity may, rarely, be avulsed by the violent contraction of the quadriceps, as in jumping; there is loss of power of extension, and displacement of the tubercle, which can be moved upon the underlying bone with crepitus. This may be treated by adhesive strapping with the leg in extension or by an open operation, the tubercle being fastened in place by a bone-peg or screw.

Separation of Tibial Tubercle (Schlatter's Disease, Osgood-Schlatter Disease, Rugby Knee).—The tongue-like process of the epiphysis, to which the ligamentum patellæ is attached, is partially separated with localized swelling and pain, aggravated by attempts to extend the knee. It is much more common than complete separation. It occurs in athletic youths between the ages of eight and fourteen years, and may even follow kneeling at drill. The separation usually is incomplete, as shown on the roentgenogram; the swelling may be mistaken for tuberculosis or other bone disease.

Treatment.—Prompt relief may follow adhesive strapping, which is renewed every week for three or four months. For persistent displacement, an incision is made and the tubercle pegged or screwed to the underlying bone, after which a case is applied with the leg in a nearly straight position.

Fig. 181.—T-fracture of the lower end of the tibia.

Shaft of the tibia is usually broken by direct violence, less often by torsion of the foot. The common site is the junction of the lower and middle thirds. As a rule, the fracture is transverse in the upper, and oblique in the lower part of the shaft. The splinting action of the fibula limits the displacement. The injury occurs chiefly in children and young adults, and is often compound.

Symptoms are pain and local tenderness, irregularity in the crest of the tibia, mobility, crepitus, and pain referred to the region of the fracture on vertical or lateral pressure. In transverse fractures there is usually little or no deformity, but in oblique fractures the upper fragment may be pulled forward by the quadriceps, the lower fragment lying behind and lateral to the upper.

Treatment.—1. *Immediate reduction:* After twenty-four hours the difficulty in reduction progressively increases.

2. *Retention* by bivalved case from toes to upper thigh. If there is no tendency for displacement, a fracture-box, and ice-bags for twenty-four hours, followed by moist fomentations, may be used until the primary swelling has subsided. Skin or skeletal traction in a Thomas splint is indicated for persistent displacement.

3. *After-treatment*, including: (a) Massage after the first week. (b) Ambulant condition on crutches after ten days. (c) Progressive weight bearing in a case after four weeks. (d) External support discontinued after six weeks. (e) Shoe to have Thomas heel, with lift on the inside of the sole to adduct foot.

Tibia and fibula are usually fractured in children and young adults. If *from direct violence*, the bones are broken at the same level, the fracture being

transverse, with great contusion and usually little displacement; when *from indirect violence*, the tibia usually breaks at the junction of the middle and lower third (the weakest point), and the fibula higher up. Most of the fractures are oblique, from above downward, forward, and inward. The lower fragment is pulled upward by the action of the calf muscles, rotated outward by the weight of the foot, and the upper fragment may penetrate the skin. The displacement may be marked or slight.

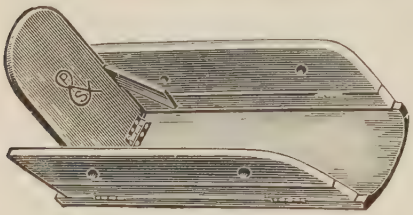


Fig. 182.—Fracture-box. The fracture box should be lined by a pillow and the sole of the foot held against the padded foot-piece by a length of bandage, the ends of which cross the dorsum of the foot from behind the ankle and are tied below the foot-piece. The hinged sides are held by two or more lengths of bandage tied around the box.

Symptoms.—Angulation, shortening, mobility, and crepitus are usually very evident. In the examination, great care should be taken to prevent further injury to soft tissues.

Treatment.—*Reduction* may be difficult. The knee should be flexed to relax the calf muscles. Division of the tendo achillis has been used, but may cause disability, especially in adults. With reduction, the inner margin of the great toe, the inner malleolus, and the inner margin of the patella are in line, and there is no deformity along the crest of the tibia or the outer edge of the fibula. Shortening and internal rotation should be absolutely corrected, and a plaster-of-Paris case applied from the toes to the upper thigh to maintain reduction. The case should be immediately bivalved, to allow for swelling and permit massage. If reduction is difficult or cannot be maintained, traction in a Thomas splint is desirable. For *skin traction*, the Sinclair skate or a stocking glued to the foot is used; for *skeletal traction*, a caliper is inserted in the malleoli, or Steinmann's pin through or above the calcaneus, the leg being swung in the splint. When reduction is complete and well maintained, a bivalved plaster case is substituted. Where reduction cannot otherwise be obtained, operative reduction and fixation is desirable, the operation being deferred eight days or until the primary swelling has largely subsided. The bony alignment should be checked by roentgenograms. Weight bearing in the case is permitted after four weeks. Support by case, brace, or walking caliper should be continued for from six to twelve weeks.

Medial malleolus may be broken by a blow on the ankle or a wrench of the foot inward. There is pain, mobility, crepitus, with effusion into the ankle-joint and with possible downward displacement of the fragment. This fracture may be followed by a stiff ankle and, if there is much displacement, wiring or pegging should be considered. If there is little or no displacement, a fracture-box may be used at first, followed by a plaster-of-Paris case. Retention is continued for four to six weeks.

Separation of Lower Epiphysis of the Tibia.—A rather rare injury, occurring between the ages of eleven and eighteen, from forcible eversion or inversion of the foot; is usually accompanied by fracture of the diaphysis of the fibula, and frequently is compound. If it interferes with the growth of the tibia, and

the foot becomes inverted, separation of the fibular epiphysis may be associated. The treatment is similar to that for *Pott's fracture.*

Fibula.—The fibula may be broken by direct or indirect violence, or by contraction of the biceps. The fracture may involve the upper end, the neck, the shaft, or the lower end of the bone. Support given by the tibia limits the displacement. In *fracture of the upper end*, the proximal fragment may be drawn upward by the biceps. An *oblique fracture of the upper third* is common, and has been shown by Bennett to result from an outward twist of the ankle while the foot is extended. Foot-drop may follow injury of the common peroneal (external popliteal nerve). *Compound fracture* of the fibula without fracture of the tibia is very rare.

Diagnosis of fracture of the fibula is made by localized pain on pressing the bones together, loss of the fibular spring, preternatural mobility, crepitus, and local swelling. On rotating the foot outward until the talus presses against the fibula, pain is produced at the seat of the fracture.

Fig. 183.—Fracture of the neck of the fibula. (Roentgenogram by Dr. G. C. Bird.)

Fig. 184.—Oblique fracture of the lower fifth of the fibula. (Roentgenogram by Dr. G. C. Bird.)

Treatment.—(1) A plaster-of-Paris case from the toes to the knee for four or five weeks, with progressive weight bearing. (2) The patient is permitted to be up with a cane or crutches from the first. (3) If the upper fragment is drawn upward by the biceps, it may be desirable to first treat the fracture with the knee flexed. (4) If there is no pain on movement of the foot and no deformity, an ambulant treatment with a simple bandage and without a splint may be all that is required. If pain follows use, the ankle should be fixed.

Fracture-dislocation of the Ankle.—Forces acting upon the ankle may produce external or internal rotation, external or internal flexion, or backward

or forward displacement. The important *forces causing fracture* are external rotation, abduction, adduction, and posterior displacement of the foot.

The *common lesion* is fracture of the lower fifth of the fibula, with one or more of the following complications: (1) Rupture of the deltoid ligament, or avulsion of the medial malleolus. (2) Rupture of tibiofibular ligament. (3) Posterior dislocation of the foot.

Pott's fracture, the most common fracture of the leg, results from eversion and abduction of the foot or, rarely, inversion and adduction, as by tripping and turning the foot.

Deformity.—The foot is rotated and displaced laterad, mediad, backward, or (rarely) upward. Characteristic lesions are:

1. *Fracture of the fibula*, usually oblique, 7 to 10 cm. above the ankle.

2. *Rupture of the deltoid (internal lateral) ligament*, or avulsion of the medial malleolus.

3. *Rupture of the interosseous ligament* with separation of the tibia and fibula, causing broadening of the ankle. Usually the foot is everted and rotated outward, and often dislocated backward. The most common form (Ashhurst) is a torsion fracture of the lower end of the fibula, the fracture line running upward and backward, due to external rotation of the foot. Instead of a rupture, avulsion of the tibial attachment of the tibiofibular interosseous ligament may occur, with a wide separation of the lower ends of the tibia and fibula, and possibly dislocation of the talus upward and between them (*Dupuytren's fracture*).

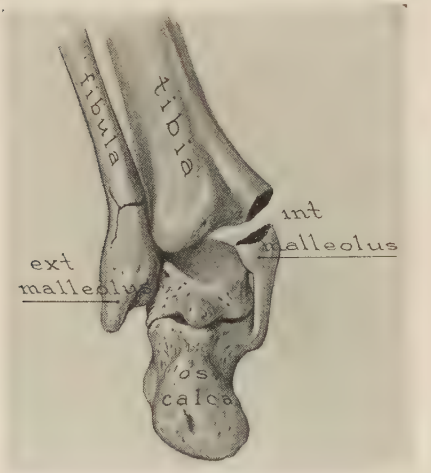


Fig. 185.—Fracture-dislocation of ankle with fracture of the lower fifth of the fibula, fracture of the medial malleolus, and eversion of the foot. The rupture of the tibiofibular band and separation of the tibia and fibula, often present in Pott's fracture, are not shown.

Fig. 186. –Fracture-dislocation of the ankle (Pott's fracture) with eversion and adduction of the foot.

Symptoms.—There may be marked deformity and complete disability, or the patient may have slight deformity and be able to walk. The foot usually is everted, the inner side resting on the ground, and it may be displaced backward between the separated malleoli. The medial malleolus is unduly prominent. There is pointed toe (from contraction of the gastrocnemius and soleus), abnormal mobility, and crepitus. Tenderness is present over the deltoid liga-

ment, medial malleolus, the inferior tibiofibular band, and over the point of fracture on the fibula. The lower fragment of the fibula may be rocked by pressure upon the lateral malleolus, producing crepitus and pain. There is a broadening of the ankle, which is extreme in *Dupuytren's fracture.*

Diagnosis.—With slight displacement, the fracture may be mistaken for a sprain of the ankle. In the fracture, the maximum tenderness is at the point of fracture; while, in the sprain, it is over the ruptured ligament. In fracture the ankle-joint is usually distended by blood.

Prognosis is good in the young, fair in adults, but poor in the aged and rheumatic, in whom pain and disability often persist. Where there is a fracture of one bone only, with little displacement complete recovery and ability to do hard work should result in three months. An adult with fracture of both bones, or a severe Pott's fracture, may have disability lasting many months. Prolonged or even permanent disability is often caused by imperfect reduction; prolonged immobilization; or by failure to use massage and passive movements, or to correct pointed toe and eversion of the foot early in the treatment.

Treatment.—The fracture should be reduced under an anesthetic, with the knee bent to relax the gastrocnemius, using traction with rotation of the foot; usually the foot should be carried mediad, forward, and downward.

Proper position: The foot should be at right angles to the leg, the heel well forward, eversion and lateral displacement slightly overcorrected. The great toe, the medial malleolus, and the patella should be in line. The weak everted flat-foot too often seen after these fractures should be prevented. A case, immediately bivalved, is applied from the toes to the knee or, if the fracture is an extensive one, to the midthigh. Daily massage is started the second, and passive movements the third, week. Crutches are permitted after ten days, slight pressure on the case after three weeks. Adhesive strapping is substituted for the case after six weeks, and weight bearing gradually resumed. After removing the case, the shoe worn should have the heel raised 4 mm., and the sole raised 3 mm., on the medial side, to prevent strain of the deltoid ligament and valgus deformity. Following incomplete reduction the residual deformity may be so great, from traumatic flat-foot with eversion, that a specially made supporting shoe or a secondary osteotomy and correction is desirable.

While a plaster case gives the best retention, it is dangerous unless properly applied and carefully watched. If skilled supervision is not available in the early treatment, the fracture-box or Dupuytren's splint is safer, while not giving as good support. After reduction the leg is placed in a well-padded fracture-box, the foot carefully fastened to the foot-piece, and ice-bags, fomentations, or evaporating lotions continued until the early reaction and swelling have subsided. The area of injury should be examined and gently massaged daily. With the subsidence of the primary swelling the accuracy of the reduction is confirmed, and a case may now be applied with greater safety. The foot is held in slight adduction and at right angles to the leg, and encased in a plaster-of-Paris bandage from the toes to the knee. Usually the patient may now be permitted to go about on crutches, slight but increasing weight bearing being permitted after the third week. The case is left off after the fifth week and, if

weakness of the ankle persists, massage and adhesive-plaster strapping should be continued for from two to four weeks longer. Dupuytren's splint is a straight board, notched at the lower end, and long enough to extend from the knee to 5 or 6 inches below the foot. This splint, thickly padded, is bandaged to the medial surface of the limb, the foot being inverted over the lower end of the pad. The splint corrects the eversion and upward displacement, but not the backward displacement of the foot.

Calcaneus (*Os calcis*) is most frequently fractured by a fall on the sole of the foot from a height. The injury may be bilateral.

Type I. Compression or Impaction Fracture.—The primary fracture is usually longitudinal, passing through the facet for the talus and cuboid, with secondary radiating fissures; the entire calcaneus may be crushed and flattened.

Symptoms.—Tenderness and pain on movement or attempts to walk. The foot is shortened, the hollows at the sides of tendo calcaneus (achillis) filled. Bony thickening below the lateral malleolus is diagnostic (Cotton), and is due to the pushing out of the lateral plate. Crepitus is absent, or the entire bone feels like a mass of fragments. The condition may be mistaken for fracture of the lower end of the fibula.

Treatment.—Cotton uses a padded mallet to disimpact and contour the bone. In reduction, an anesthetic should be given and the foot molded in position; the arch being restored; the foot being inverted, and held at right-angle flexion by a plaster-of-Paris case from toes to knee, which is worn for six weeks. Massage is started the second week, passive movements the third, active movements the fourth, and weight bearing with a fitted arch supporter the sixth week. The local tenderness may persist for months, but a final satisfactory result may be expected, except in the old, obese, or rheumatic patients. Skeletal traction by Steinmann's pin or calipers is at times desirable. From fractures of the os calcis, flat-foot, lateral displacement of the heel, limitation of lateral movement, exostosis, or painful plantar spur formation may occur, which may be more or less completely relieved by support, exercise, or by osteotomy, arthrodesis, or other operation.

Type II. Fracture of Tuberosity.—Rarely, from a fall on the ball of the foot, the posterior fragment of the bone or the epiphysis is pulled off by the calf muscles and, if completely detached, is retracted to a higher position.

Treatment.—Adhesive strapping over fragment, and bivalved case from toes to upper thigh, with flexion of knee and strong plantar flexion of the foot. If this fails to reduce the displacement, the fragment is pegged or otherwise retained in position through an open operation. Weight bearing with the heel raised may gradually be resumed after six weeks.

Type III. Fracture of Sustentaculum Tali.—A rare fracture through the articular facet or the sustentaculum, caused by a fall with the foot in inversion or dorsiflexion.

Symptoms.—Medial plantar tenderness over the anterior part of the calcaneus. Pain with limitation in movement, but with little or no deformity.

Diagnosis is confirmed by the roentgenogram.

Prognosis.—Flat-foot tends to follow from associated injury of the calcaneonavicular part of the bifurcated ligament.

Treatment is similar to that for Type I, with prolonged support of the plantar arch.

Talus (*Astragalus*) usually is fractured as the result of a fall, being crushed between the tibia and the calcaneus. An impacted fracture and one through the neck are recognized. It often is complicated by fracture of the calcaneus and tibia. Fracture by direct violence also occurs. The injury is often mistaken for a sprain of the ankle, as crepitus is absent and the swelling obscures the deformity. In the roentgenogram, the *os trigonum tarsi* may be mistaken for a fragment from fracture.

The **treatment** is immobilization in a case, with the foot at right angles and slightly inverted, for five to six weeks. Massage is started at the end of one week, and passive movements at the end of two weeks. Should there be

Fig. 187.—Fracture of second and fifth metatarsals. (Roentgenogram by Dr. G. C. Bird.)

persistent deformity and disability, arthrodesis should be done or the bone excised.

Tarsus.—The remaining bones of the tarsus are rarely fractured alone. The tuberosity of the *navicular* may be torn away by the contraction of the ligaments attached to it, or the bone crushed by a fall. The *cuboid* may break from direct violence.

Metatarsals and **phalanges** are often broken as a part of a crushing injury; the fracture is frequently compound. Limited fracture of one of the metatarsals or phalanges, with slight displacement, often follow relatively slight injuries, as a kick or stubbing of the toe. Often the diagnosis can be made only by roentgenogram. The fracture is caused either by direct or indirect force.

For *crushing injuries* the parts should be molded into proper position. The treatment should restore the normal angle of the foot, maintain abduction, and

prevent pointed toe or traumatic flat-foot. A molded splint from toes to knee may be used for four weeks, followed by the use of soft arch supporter for two or three months. Weight bearing is gradually resumed after six weeks. For marked displacement, traction as for the bones of the hand may be used. For simple fracture of the phalanges without displacement, a simple wrapping with adhesive plaster for two or three weeks often suffices. For a phalanx of the great toe, a well-padded plantar splint may be used.

Base of the Fifth Metatarsal.—*Fracture* is caused by a thrust on the lateral edge of the inverted foot while the heel is raised. It often occurs in dancing. There is swelling and local tenderness over the base of the fifth metatarsal, and pain when the patient puts weight on the foot, but no crepitus or deformity.

Diagnosis is confirmed by the roentgenogram. Massage and passive movements should be employed from the first, with a simple bandage or strapping.

Sesamoid of Great Toe.—The internal sesamoid is the more frequently broken.

Etiology.—Fall upon the great toe, or abduction and dorsiflexion of the toe from a blow.

Symptoms.—Moderate pain; swelling and tenderness over the ball of the foot. A bipartite sesamoid shows a median, regular cleft, and is usually bilateral.

Treatment.—Absolute fixation in plaster for three weeks, followed by the wearing of a shoe with a pad under the anterior arch, and with a rigid sole to prevent dorsiflexion of the toe. In chronic cases (not relieved by the above support) the bone should be excised.

Freiberg's infraction of the metatarsal head (*Köhler's metatarsophalangeal syndrome, juvenile deforming metatarsophalangeal osteochondritis*) is of unknown etiology and usually occurs in girls between the ages of ten and eighteen. The second or occasionally the third metatarsal, rarely both, are involved.

The diagnosis is made from the roentgenogram which shows broadening of the metatarsophalangeal joint space, flattening of the neck and distal portion of the shaft, with a resultant disappearance of the constriction of the neck. There is absorption in the head, suggestive of sequestration, with irregularity of the articular surface of the proximal phalanx. The condition may cause discomfort or pain on pressure or movement. Treatment consists in a well-fitted shoe and foot-plate, or operative resection of the head and neck of the involved metatarsal if the disability is not otherwise relieved.

CHAPTER XVI

THE JOINTS

Examination and General Diagnosis.—Swelling and alteration of contour may originate from changes in the soft tissues, bones, or in the synovial membrane. Excess of fluid in the joint is shown by swelling, limited to the distensible membranes, and a fluid wave or fluctuation; with the knee there is a floating patella and ballottement. Distended adjacent bursa or tendon sheaths do not give the contour of a distended joint. With disease of the bone ends, nocturnal osteocopic pain is present. With malignant tumors of the bone ends, there is no limitation of movement in the joint. With tuberculosis or other inflammation of the epiphysis, there is early effusion into the joint, and pain on movement with more or less fixation from muscular spasm. Marked edema, redness, and tenderness suggest purulent inflammation; absolute, painless fixation of the joint evidences bony ankylosis; fixation that may be painful, with a slight give on pressure, indicates fibrous ankylosis; partial fixation, with muscular spasm and pain on movement—an arthritis or synovitis. Free painless movement, restricted within a limited arc, suggests false or extra-articular ankylosis which may follow fracture or dislocation. Grating, with pain on movement, indicates an arthritis with destruction of cartilage and, perhaps, associated bone disease. Painless grating occurs in chronic osteo-arthritis, Charcot's joint, in syringomyelia, chronic hemophilia, and some forms of chronic serous synovitis. Free movement under an anesthetic shows the absence of organic ankylosis. Absence of active movement, with free passive movement, occurs in paralysis of peripheral nerves. Greater pain on active than passive movement, increased by vertical pressure, indicates disease of the cartilage and bone.

Roentgenogram.—In gonococcic, typhoid, tuberculous, or syphilitic arthritis there is no bony overgrowth, but an adhesive fibrous ankylosis.

In osteo-arthritis there is *lipping* of the osteochondral edges, and *spurring* of the osteocapsular edge.

Acute Synovitis.—An inflammation of the synovial membrane of a joint, with redness, swelling, and the exudation of serous, fibrinous, or cellular products. If the process is infectious, the inflammation may spread to the articular cartilage, bone, ligaments, and adjacent soft structures (*arthritis* or *panarthritis*).

Etiology.—Acute synovitis follows: (1) Injury from without the joint, as a sprain, contusion, articular fracture, or penetrating wound; (2) trauma from within the joint, as from joint-mice, rice-bodies, hypertrophied fringes, or displaced cartilage; (3) pyogenic infection.

Symptoms.—Pain, increased by movement; local tenderness over the synovial membrane, swelling, and change in contour. Ecchymosis is rare without associated fracture. From distention, the joint is usually semiflexed.

Diagnosis.—In arthritis there is involvement of the bone and perisynovial structures. A tuberculous arthritis is evidenced by muscular spasm, progressively

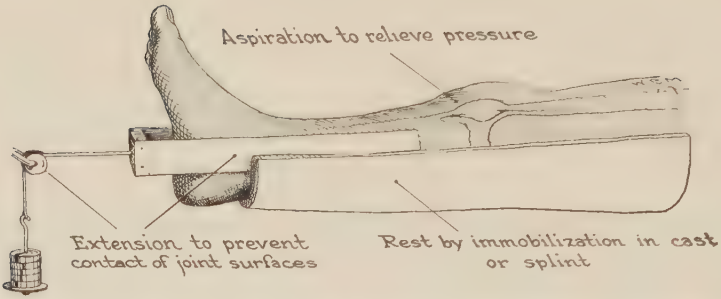

Aspiration to relieve pressure
Extension to prevent contact of joint surfaces
Rest by immobilization in cast or splint

Fig. 188. Important therapeutic points to be observed in the treatment of an acute arthritis or synovitis.

increasing deformity and muscular wasting, and may follow an injury. Sprain is characterized by symptoms immediately following severe injury, with marked swelling and ecchymosis. In hemophilic joint (*hemarthrosis*) the rapid joint effusion and swelling follow trivial injury, with little pain, and with bloody fluid on aspiration.

Fig. 189.—Method of strapping the ankle for injury of the medial ligaments. In the usual sprained ankle the lateral ligaments are involved and the strips of adhesive plaster should therefore be applied to the lateral side of the foot and leg.

Prognosis.—Without infection, fracture, or abnormal bodies within the joint, the prognosis is good. Inflammatory products are gradually absorbed, the pain subsides, and the stiffness usually disappears on use.

Treatment.—(1) Immobilization by splint, case, bandage, or adhesive strapping. (2) Cold compresses, evaporating lotions, or an ice-cap, for the first twenty-four hours, followed by hot fomentations and in the later stages absorbents, as mercurial or belladonna ointment. (3) Baking, massage, and passive movements only to the point of producing pain; active movement to be resumed as soon as the movement is painless. For *adhesions without inflammation or infection*, free mobilization under an anesthetic. For *adhesions with infection or inflammation*, extension to prevent displacement and to place the joint in the position of optimum function. For the *displacement of cartilage* or the tearing of an important ligament of the joint, immobilization by case, strapping, or brace should be continued for three months.

Sprained ankle usually results from inversion and twisting of the foot, with stretching and tearing of the lateral ligaments. Swelling, discoloration, and tenderness are present over the lateral ligaments; adduction is painful, abduction not.

The foot should be elevated and put at complete rest, with the local application of cold, wet compresses of magnesium sulphate, aluminum acetate, or boric alcohol; with support and fixation until the acute swelling has subsided. The foot, ankle, and leg are then firmly strapped by long strips of adhesive plaster, holding the foot in dorsiflexion and abduction. The strapping is reinforced by a roller bandage. With the strapping, the patient can at once go about. The strapping is continued, with renewals as necessary, until all swelling and pain have subsided. In the later stages hot baths, massage, and baking are of value.

Sprains of other joints are treated by adequate support and fixation, with adhesive strapping or other supportive dressing.

Chronic Synovitis.—Etiology.—Chronic irritation from: (1) Loose cartilage, thickened synovial fringes, or foreign body. (2) Mild pyogenic infection. (3) Chronic subacute infection from tuberculosis or syphilis.

Pathology.—The capsule is distended, producing a characteristic change in the outline of the joint. In the knee, the patella is elevated from the femur (*floating patella*). Fluctuation may be apparent. There is thickening of the synovial membrane, hypertrophy of the villous fringes, and the cartilage may be rough and fibrillated. The joint is usually weak and unstable, but there is little pain or tenderness.

Treatment. (1) Rest and fixation by case, splint, or brace. (2) Aspiration and possible injection of the joint. (3) Removal of foreign bodies or hypertrophied fringes.

Hydrarthrosis (*Hydrops articuli*), a chronic distention of a joint with serous fluid, is a symptom of chronic serous synovitis, osteo-arthritis, Charcot's joint, syphilitic and tuberculous synovitis.

Baker's cysts (Morrant Baker) are pouches of synovial membrane that protrude through the capsular ligament. They may extend for a considerable distance into the adjacent soft tissues and, at times, lose communication with the cavity of the joint. Several cystic diverticula may be associated with a single joint. Usually they are due to a chronic synovitis or hydrops of the joint.

Symptoms.—Painless or moderately tender cystic swelling adjacent to a large joint, particularly the knee, showing synovial fluid on aspiration.

Treatment.—Excision under very careful aseptic precautions, if pain or disability are produced.

Hemarthrosis (*bleeder's joint* in *hemophilia*) is characterized by sudden hemorrhage into the joint, occurring from slight injury, in boys with hemophilia, involving especially the knee, the ankle, wrist, elbow, shoulder, and hip. The synovial cavity is suddenly filled with blood, which may remain unabsorbed for months, with secondary fibrillation and nodular thickening of the cartilages, synovial membrane and fringes, relaxation of ligaments, and chronic and recurrent synovitis. Later an osteo-arthritis with lipping and roughening of the bone, or fibrous adhesions and fibrous ankylosis may develop.

Treatment is that for hemophilia. Operation, or aspiration of the joints, should be avoided. The joints should be put at rest in an elastic bandage, with fixation, pressure, and cold applications.

Loose bodies in joints consist of fibrin, clots, and bits of cartilage, bone, or synovial membrane. They vary in size from a few millimeters to several centimeters, being known as *rice-bodies*, *melon-seed bodies*, and *joint-mice*. They are chiefly found in the knee, occasionally in the elbow, rarely in other joints.

Symptoms.—The loose substance may produce locking of the joint, with acute pain and synovitis. A slipping body may be felt.

Diagnosis is made from detached semilunar cartilage or enlarged synovial fringes.

Treatment.—Operative removal, best performed after transfixion of the located body with a needle. It may be very difficult to find the body in the joint, unless it has previously been fixed.

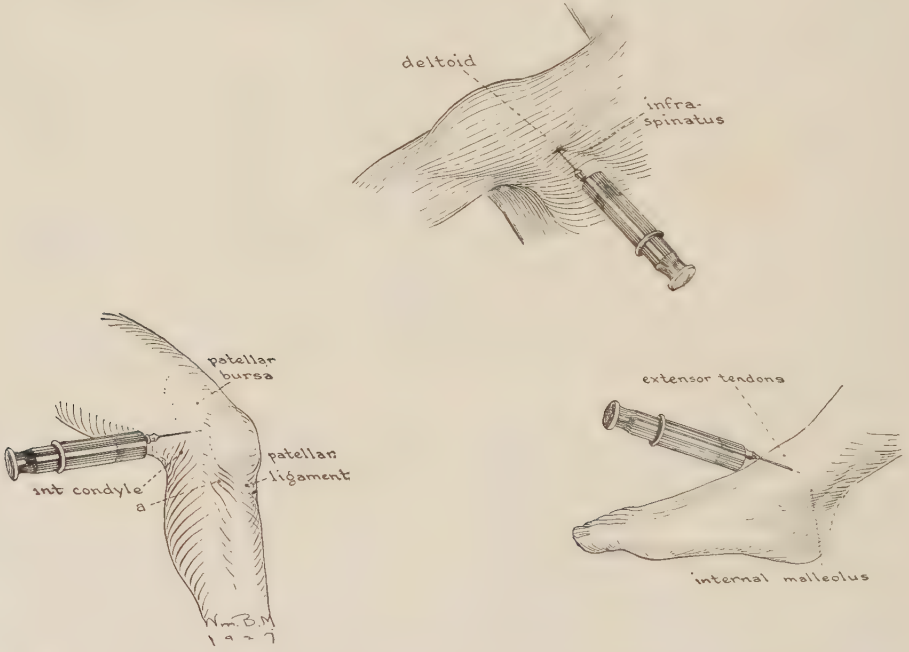


Fig. 190.—Points for the introduction of a needle in aspirating or injecting the shoulder-, knee-, or ankle-joint. The knee-joint also may be entered lateral to the patellar ligament (*a*).

Acute arthritis involves all the structures of a joint, including synovial membrane, cartilage, ligaments, and bones.

Etiology.—Pyogenic bacteria entering the joints: 1. *Through open wounds.* 2. *Through the blood-stream*, from: (a) Pneumonia (*pneumococcal arthritis*); (b) gonorrheal infection from the urethra, prostate, or conjunctiva (*gonococcal arthritis*); (c) foci about the teeth, tonsils, adenoids, nasal sinuses, gall-bladder, appendix, or the like—usually *streptococcal arthritis;* (d) measles, scarlet fever, influenza, smallpox, and other acute exanthematous diseases—usually *streptococcal arthritis;* (e) pyemia (*pyemic arthritis*); (f) rheumatism (?) (*diplococcal arthritis* [?]).

Pathology.—(1) Exudation of serum, plasma-cells, leukocytes, and fibrin factors from the synovial membrane; desquamation of endothelial lining and formation of granulation tissue. (2) Cartilage becomes yellow and eroded at points of pressure, exposing the bone; or exfoliates and separates from the underlying bone, and is replaced by granulation tissue from the bone beneath. (3) The ligaments are infiltrated, become edematous and softened, and may be perforated or destroyed. (4) The articular surface of the bone is denuded, eroded, and may become necrotic with osteoporosis and caries. The process does not extend to the apophyses, although the adjacent periosteum may become inflamed. The pus may escape into adjacent soft tissues, which are burrowed by large abscesses.

Symptoms.—Acute pain in the joint, increased by pressure or movement; swelling from distention of synovial membrane, and edema and swelling of the outer tissues. The joint assumes a position of moderate flexion, with adjacent muscular spasm which, when relaxed during sleep, causes *starting-pains*. The overlying skin becomes red, hot, and swollen. Large periarticular abscesses may form, with secondary sinuses, and pathologic dislocation occur from destruction of ligaments and loss of muscular tension.

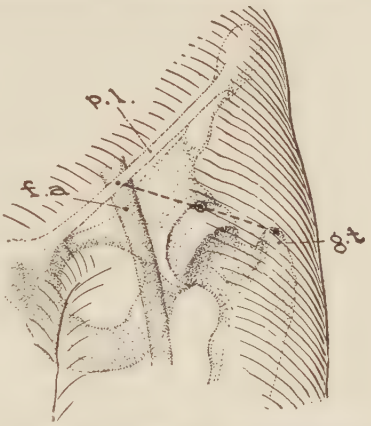


Fig. 191.—The point for aspiration of the hip-joint lies midway between the tip of the great trochanter and the point where the femoral artery crosses the ligamentum inguinali.

Prognosis.—Dislocation often follows typhoidal arthritis of the hip. In all forms of purulent arthritis a good functional result may be expected if the disease remains limited to the synovia, and if the cartilages are not eroded or the bone destroyed. Severe pneumococcic and suppurative arthritis is often fatal. Relapses are common in gonorrheal arthritis.

Treatment.—1. *Absolute immobilization* by case or splint, in the position of optimum function.

2. *Extension* to separate the joint surfaces.

3. *Aspiration* to remove inflammatory exudate and to relieve tension.

4. *Injection* or *irrigation* of the joint with: (a) Phenol, 2 to 5 per cent. solution; (b) acriflavin (1 : 1000); (c) metaphen (1 : 5000), or (d) the injection of 5 to 15 c.c. of 2 per cent. formalin in glycerin (Murphy). If suppuration progresses despite repeated aspiration, injection, or irrigation, one or more of the following procedures are indicated:

5. *Arthrotomy.*—A free incision into the joint is made, and drains are introduced down to the opening in the synovial membrane, but not through it. For the knee, incisions are made at the side of the patella or, better, posteriorly; a vertical incision being made on either side, to the popliteal side of the hamstring tendons.

Willem's Treatment by Drainage with Movement.—Under extension made by a properly arranged weight and pulley, after arthrotomy with drainage, the

patient is encouraged to freely flex and extend the joint. These movements grow progressively less painful, and actively force the purulent products from the synovial cavity. The method is especially valuable in purulent arthritis from open wounds by reducing the tendency to ankylosis.

If drainage by arthrotomy fails—

6. *Arthrectomy and Erasion.*—By a sharp chisel or curet resection of the diseased articular surfaces is made. Abscesses in the soft tissues should be freely drained. In extreme cases amputation is necessary to save the life of the patient.

Typhoidal arthritis occurs during convalescence from typhoid fever as a *pure infection* by the *Bacillus typhosus*, or a *mixed infection* with other pyogenic organisms. Pure typhosus infection is associated with little pain, marked effusion, and secondary relaxation of ligaments, with little tendency to spread outside of the synovial membrane. One or more aspirations should be used to prevent overdistention of the synovial membrane. Unless there is a mixed infection, the process is usually mild and is followed by recovery, although spontaneous dislocation may occur from the marked effusion and the stretching of ligaments.

Pneumococcal arthritis occurs as a complication or sequel to pneumonia, or from a focus of chronic infection in the patient's body. It predilects the larger joints with the exception of the hip, especially the knee, and (in males) the joints of the upper extremity.

Gonorrheal arthritis may be manifested as a synovitis with effusion, or as a periarticular inflammation. It involves chiefly the knee, ankle, and wrist; with marked swelling, edema, redness, extreme pain and tenderness, and with a serofibrinous, seropurulent, or greenish purulent effusion into the joint. There is no destructive suppuration. The process usually is chronic, resists treatment, and is often followed by ankylosis. Several joints may be lightly affected, the process later concentrating upon one or two. The fluid from the joint may be sterile. There is no *lipping* at the osteochondral edges, nor *spurring* at the osteocapsular edge of the joint.

Etiology.—It is more common in men, in the third week of acute gonorrhea, and especially with posterior urethritis. It also follows instrumentation in gonorrhea, gonorrheal ophthalmia, and occurs in infected women after pregnancy or labor.

Prognosis.—The arthritis is prone to be chronic (especially if the primary urethritis persists), continuing for years, destroying the function of the joint, and leaving a fibrous ankylosis when the inflammation subsides. The synovial membrane proliferates, adhesions fix the joint, the cartilage becomes fibrillated, the muscles undergo atrophy, and pain continues until complete ankylosis results. The wrist is especially affected in women.

Treatment.—The local treatment is similar to that for other forms of purulent arthritis: Absolute rest, extension, aspiration—repeated, if necessary, with irrigation of the joint.

Protein-shock Treatment.—An intravenous injection of 1 to 5 minims of typhoid or gonococcus vaccine, or of $\frac{1}{2}$ to 2 c.c. of sterile milk, is made. Within half an hour this is usually followed by a violent chill, succeeded by a temperature

of 104° to 106° F. A single injection may suffice, or after five or six days, if the condition does not improve, a second injection may be given. The subcutaneous injection of gonococcus vaccine is occasionally of value. Recovery, chronicity, or fibrous ankylosis may follow.

Pyemic Arthritis.—Arthritis occurs during pyemia, the joint becoming rapidly distended with pus, often with little pain or local reaction. The patient's life is threatened by the general condition, but the infection of the joint will often improve under rest, aspiration, and irrigation.

Rheumatic arthritis is a name given to an acute and fleeting form of polyarthritis, which may develop chronic manifestations. One joint after another is infected, the synovial membrane being chiefly involved, with effusion, adhesions, fibrous ankylosis, and recovery without suppuration.

The **treatment** is that for rheumatism, with salicylates, iodids, alkalies, vaccines, and the use of protein shock. *Locally:* Rest, support, baking, applications of methyl salicylate, and aspiration and irrigation of the joint if there is much effusion.

Tuberculous Arthritis.—Etiology: (1) Childhood and early adult life. It is rare under one year of age, and only occasionally occurs in elderly persons. (2) Traumatism. (3) A preceding general infection, especially measles, whooping-cough, scarlet fever, or pneumonia.

Pathology.—Tuberculosis begins in the synovial membrane or end of a bone, the articular cartilage and ligaments being involved secondarily. There is a deposit of tubercles, with effusion and secondary caseation; the synovial membrane becoming thickened, edematous, and granular. The hypertrophied synovial membrane may extend over and cover the joint (*synovial pannus*) and may or may not be attached to the degenerated cartilage. Adhesions form, fluid exudate fills the joint, and the ligaments are early invaded and destroyed. The disease spreads over and under the cartilage, the adjacent bursa may become infected and form Baker's cysts. *Rice-bodies* (small, hard, white, smooth, slippery bodies) are sometimes found in tuberculous joints, with marked atrophy of adjacent bone and tendons. In bone, the process begins beneath the articular cartilage in the epiphysis or, rarely, in the diaphysis next to the epiphysis. Necrosis, osteosclerosis, caseation, suppuration with separation of articular cartilage, distention of the capsule, destruction of bone ends, and secondary dislocation occur, and periarticular cold abscesses form. There is no exostosis; the bone may undergo fatty change, with so-called *fatty osteomalacia.* Bony union rarely takes place without operation.

Symptoms.—(1) *First stage*—Pain, stiffness, and swelling of a joint with change in attitude, local increase in temperature, muscular spasm, and early muscular atrophy. *Early distention* of the synovial membrane (*white swelling*) occurs, with flexion of the joint in a position to permit the greatest distention. Suppuration is rare, the joint feels rather doughy. Movement, both active and passive, is limited and painful. If the bone is involved, the symptoms are more marked, active movement and pressure are painful, while passive movements are painless. *Referred pain:* From tuberculosis of the spine, the pain is referred to the back, chest, arms, abdomen; from the hip, to the inner side of knee. Thus the symptoms may simulate a disease of the abdomen or knee.

(2) *Second stage—fixation;* the joint is held by muscular spasm. The attitude at first is due to the contraction of uniarticular muscles, or those passing over the affected joint alone; but later to multi-articular muscles, or those passing over more than the one joint. *Starting-pains* occur at night (*night cries*), especially when the cartilage is eroded and the relaxed muscles suddenly contract, bringing the eroded surfaces together. (3) *Third stage—destruction*, with disintegration of ligaments, cartilages, and bone; secondary fixation, wasting, deformity, shortening, abscess formation, dislocation, and general septic or amyloid changes.

The pure synovial cases are milder, and may last one or two years with little pathologic change.

Roentgenogram: The bone appears worm-eaten, thickened, or condensed. The shaft may show atrophy; the epiphyses (in children), furred edges; and the joint capsule, thickening.

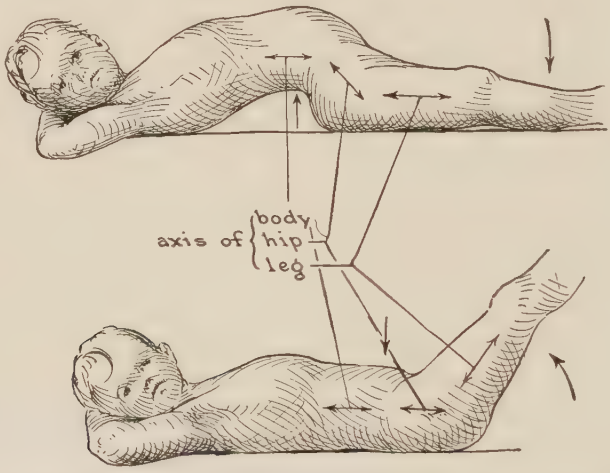


Fig. 192.—Test for fixation of the hip-joint in morbus coxarius. The lumbar spine is raised on depressing the affected side.

Complications.—Include pulmonary tuberculosis, meningitis, tuberculous peritonitis, amyloid disease.

Diagnosis.—A slow, progressive uniarticular arthritis in childhood or youth, in association with tuberculous lesions in other parts of the body is characteristic of a tuberculous origin. Unless an abscess forms there is an absence of acute exacerbations. Roentgenograms show the worm-eaten rarefying osteitis, with areas of increased density in the very chronic form.

As a tuberculous arthritis may follow an injury to a joint it should be differentiated from an acute traumatic lesion. Sprains give acute symptoms and are of short duration. An intracapsular fracture or an epiphyseal separation gives immediate disability and the lesion may be demonstrated on a Roentgen-ray film.

Sarcoma and giant-celled tumors occur in the metaphyses, do not involve the joints, do not affect motion, are without muscular spasm, and occur in persons apparently of good health.

Scurvy is associated with a very painful swelling near the joint.

Charcot's joint occurs in tabes or syringomyelia: Without pain; with a loose, wobbling, creaking, grating joint, containing fragments of bone and cartilage, and with unrestricted motion. It may have a sudden onset, the joint filling suddenly and painlessly with fluid.

Prognosis generally favorable under skilled treatment, except in children under three, adults over fifty, and in the presence of mixed infection or other serious invasion. The process may be arrested, with: (a) Recovery; (b) fibrous ankylosis; (c) bony ankylosis, or (d) dislocation and cold abscess formation. The smaller the joint, the better the prognosis. Tuberculosis of the sacro-iliac articulation is usually fatal. A good functional result is rare in adults, the joint usually being lost; but children recover with good function, with fibrous ankylosis, or, if secondary infection has occurred, with bony union. In adults there is always fibrous ankylosis, and at any time the process may be relighted by trauma or followed by secondary metastatic infection to the meninges or other part.

Fig. 193.—Bilateral tuberculous hydrarthrosis simulating Clutton's joints. Associated tuberculous lesions in the thorax (Stokes).

Treatment.—1. *Constitutional hygienic treatment* of tuberculosis by ample nourishment, fresh air, and sunshine.

2. *Local Conservative Treatment:* Rest, including immobilization and fixation by gypsum support, or brace, and separation of joint surfaces by extension. Local inunctions of 5 per cent. guaiacol in lanolin; injections of iodoform emulsion—iodoform, 10 parts; water, 20 parts; glycerin, 80 parts—have a limited value. Bier's passive hyperemia, baking, and radiotherapy are used. The pain is often relieved by counter-irritation (blisters or cautery). Tuberculin is of very limited value.

3. *Operative Treatment.*—Mixed infection or drainage should carefully be avoided. (a) *Partial excision, erasion,* or *arthrotomy.* The removal of diseased synovial membrane, ligaments, and cartilage, in an attempt to preserve a movable joint, usually fails. It should only be used in children under ten without bone involvement. (b) *Joint resection*—with removal of cartilage, infected ligaments, synovial membrane, and bone ends—is to be used for definite bone disease, for abscesses, or for ankylosis in a faulty position. The patient should be between five and thirty years of age and free from serious visceral involvement or septic sinuses. (c) Spinal fixation by the operation of Albee or Hibbs is used for Pott's disease. (d) *Amputation* is used for dangerous mixed infection, incurable or extensive bone disease, or where the limb is otherwise useless.

In children, the treatment is usually non-operative, for fear of damage to the epiphyses; amputation being used when other measures fail; in adolescence, fixation by apparatus, or, if this fails, operative resection. Conservative

measures are unsatisfactory in adults, and radical operative treatment is indicated. Except in the very early stages complete resection for disease of the wrist or ankle is necessary. Well-localized calcaneal tuberculosis should be treated by erasion without invasion of the joint. For tuberculosis of the finger- or toe-joint of an adult, amputation is the best treatment. For the hip or spine, an ankylosis is produced, as by Albee's operations. Cold abscesses should be prevented from becoming infected, and are emptied by aspiration rather than by incision. Injection into the abscess cavity is of limited

Fig. 194.—Syphilitic hydrarthrosis of the knee (Clutton's joint). Boy, aged twelve, with old interstitial keratitis, Hutchinson's incisors (?), sabered tibiæ, positive blood Wassermann. Relieved by arsphenamin injections and inunctions of mercury. True arthritis is absent in Clutton's joint. (Stokes.)

value. For abscesses with mixed infection injections of bismuth paste may be tried.

Syphilitic Arthritis.—1. *Early Syphilis: Arthralgia*, chiefly nocturnal, occurs without structural or functional change. *Hydrarthrosis*, characterized by simple serous effusion, without other structural, functional, or local symptom; usually bilateral and symmetric, involving the knees, elbows, and ankles; occurs in hereditary syphilis, and in early and recurrent forms of syphilis. *Arthritis*, *polyarthritis*, and *synovitis* (*syphilitic pseudorheumatism*) occur rather rarely in early syphilis with inflammatory changes, usually symmetrically in-

volving the larger joints, and with little tendency to shift from joint to joint. There is slight pain, fever, or functional or constitutional disturbance.

2. *Late Syphilis: Gummatous osteo-arthritis* and *osteochondritis* (*pseudo-white swelling*) are frequently associated with gummatous osteomyelitis, with extension of the combined proliferative and destructive processes to the joint surfaces and articular cartilages and, in extreme cases, with cutaneous lesions and gummatous involvement of the periarticular tissues. The osteo-arthritis involves the larger joints, especially the knees and elbows, and is often asymmetric. The joint is large, pale, tense, with shiny skin, there is little pain or tenderness, little limitation of movement, rarely ankylosis, and little constitutional reaction. It resembles tuberculous arthritis, but is less destructive. In syphilis, the veiling on the roentgenogram runs parallel to the cortex, and the shaft remains relatively clear and uninvolved.

Fig. 195.—Bilateral Charcot knee. Symptoms for five years following cut of the right knee. The knees became wabbly three years ago. Man, aged forty-eight, with benign type of tabes (Stokes).

3. *Hydrarthrosis of the knees* (*Clutton's joint*, 1886) is a symmetric, painless hydrops, affecting the knee-joints, occasionally the elbows, frequently associated with an interstitial keratitis.

4. *Syphilitic osteochondritis* (*von Gies' joints*) is a chronic syphilitic chondro-osteopolyarthritis which may lead to ankylosis, occurring in older children from hereditary syphilis. It resembles a tuberculous white swelling and may show both sinus formation and sequestration, and a negative Wassermann. The absence of fever and local adenopathy, and the painlessness, mobility, and response to treatment suggest syphilis.

5. *Syphilitic dactylitis* is to be distinguished from tuberculous dactylitis, in which the shaft is invaded and the periosteum bulges over a sharply defined area of destruction.

6. *Tabetic arthropathy* or *Charcot's joint* (Charcot, 1868) involves the larger joints—especially the ankle, knee, hip, or shoulder—of tabetic males, who usually give a negative blood and spinal-fluid Wassermann. It is excited by trauma in 17 per cent. (Stokes). The process begins with a serous effusion, followed by enlargement, bony overgrowth, and distortion with marked painless hypermobility.

Diagnosis from tuberculosis is made by the great bony overgrowth, absence of muscular spasm or pain, and marked instability of the joint, with painless weight bearing in a person with locomotor ataxia.

The roentgenogram shows a proliferative and destructive process, with extracapsular ossification, fluid in the joint, enlarged villi in the cavity, subluxation, osteophytes, increased circumference of the bone, and spontaneous fracture (Carman). The roentgenographic changes of other forms of syphilitic

Fig. 196.—Typical Charcot knee (Stokes). Roentgenogram of knee shown in Fig. 195.

arthritis are not very characteristic, unless gummata, periarthritis, or other bone changes are present.

Charcot's joint in children (*juvenile tabes*) also occurs. In syphilitic osteochondritis there is no lipping, the cartilages are punched out rather than worn away, and operation is not indicated.

Treatment of Charcot's Joint.—Support by brace or other device, protection from injury, aspiration of fluid, general antisyphilitic treatment.

Osteo-arthritis, rheumatoid arthritis, arthritis deformans, hypertrophic arthritis, degenerative arthritis, morbus coxæ senilis, *chronic rheumatism of the spine, osteo-arthritis of the spine, spondylitis rhizomelica* (von Bechterew's type involves the spine alone; Strumpell-Marie type, the hip- and shoulder-joints and spine).

Varieties.—(1) The *acute form* in children (*atrophic polyarthritis* of boys,

Still's disease) is associated with fever, and enlargement of the lymph-glands and spleen, the periarticular tissues being chiefly affected. It occurs during the second dentition (age three to six). There is a gradual or acute, fusiform, periarticular swelling; also muscular wasting, generalized lymphadenopathy, splenomegaly, moderate fever, and sweating, with gradual progress and exacerbations. The condition is often fatal from intercurrent disease. (2) The *acute polyarticular form* is more common in young patients, especially in women. (3) *Chronic polyarticular form* in middle-aged women, chiefly affecting the hands and feet, the large joints, and spine; later with associated atrophy and hyperplasia of bone. (4) The *chronic monarticular form* often follows traumatism in elderly patients, with atrophy of the tissues of the joint, especially the larger joints, as the shoulder, hip, or knee. Atrophy of the synovial membrane is more common in the elderly, with dryness and absence of synovial fluid. More frequently there is hypertrophy, hyperplasia with thick fibrous fringes, pedunculated or loose fibrous or cartilaginous bodies, or fat-filled fringes (*lipoma arborescens*), and an increase in the synovial fluid.

Pathology.—The condition is characterized by inflammation and degeneration of the synovial membrane, degeneration of marrow, and atrophy and hyperplasia of bone and cartilage. There is infiltration and proliferation of bone-marrow, fibrillation and degeneration of cartilage; with erosion and destruction, fibrous adhesions and, at times, bony ankylosis. The cancellous tissue either becomes more spongy or dense. Bone atrophy, minute bone-cysts, secondary subluxation and distortion, fibrous and bony ankylosis occur. Projecting osteophytes form (*spurring*) with *lipping* at the margin of the articular surfaces.

Etiology.—(1) Pre-existing focus of infection in the nasopharynx, mouth, gall-bladder, or elsewhere. (2) Preceding exanthematous disease or acute infection. (3) Traumatism may act as an exciting cause.

Symptoms.—Insidious; the more acute forms begin in the wrist- and finger-joints, then involve the ankles, tarsal joints, the hips, knees, and shoulders, and finally the spine. The skin is pale, glossy, waxy, or reddened. There is swelling, at first soft, enlargement of the bony ends, the articular edges are everted and lipped, with harsh grating or crunching (*snow-ball crunching*) on movement. The joint becomes spindle shaped. The joint movements are limited by pain, muscular spasm, and the locking of osteophytes; the condition being worse after rest and better after exercise. The usual position is that of semiflexion. Pathologic dislocation is rare. The disease is usually symmetric, bilateral, and effects one joint after another. There is atrophy of muscles, muscular cramp and spasm, bursal and synovial swelling; *Baker's cysts* may occur. In the hand, the first phalangeal joint becomes spindle shaped, the wrist is puffy, the fingers undergo ulnar adduction. *Heberden's nodes* are osteophytes growing at the base of the phalanges. In the foot, *hallux valgus* and *pes planus* follow. Increased pulse rate, general weakness, coldness and tendency to cyanosis, vasomotor changes, constant sweating, and patchy pigmentation are attendant symptoms.

Diagnosis.—Tuberculosis is monarticular and less painful, but more progressive. Gout involves well-to-do males, and has a sudden onset in the great toe.

Prognosis is unfavorable. The condition may become arrested, but is usually progressive. The disease spreads, usually centripetally, from the periphery toward the center. The patient becomes more and more bed-ridden and crippled, and shows malnutrition, a thin, dry, harsh, or glazed skin, and, from lack of care, bed-sores. The blood shows anemia and often moderate leukocytosis.

Treatment.—Removal of all the foci of infection. Iodids and salicylates are of little use, mercury and salvarsan may be of some value. Protein-shock treatment by the intravenous injection of sterile milk or bacterial vaccine may be tried. The nutrition should be improved. Operative treatment is rarely of value.

Neuromimetic, hysterical, or neuralgic joints (Benjamin Brodie, 1822) are characterized by the prominence of subjective symptoms, and the absence of pathologic changes. They are found (especially in young women) after emotional disturbance or accident, or as an imitation of a condition seen in another person.

Symptoms.—Hyperesthesia of the skin, while deep pressure is painless, with disappearance of pain when the patient's attention is diverted. Fixation of the joint is present or absent. The joint may be held rigid for long periods of time.

Treatment.—Re-education and suggestion after examination and mobilization under an anesthetic. Splints and support should be avoided. For stiffness of joints due to functional muscular spasm, the relaxation produced by a local anesthetic, especially spinal anesthesia, may be curative.

Adhesions within the joint produce limitation in movement, no pain occurring until the movement puts strain upon the adhesions. In arthritis, any degree of movement is painful.

Treatment.—In the absence of arthritis or tuberculosis, free manipulation and breaking up of the adhesions under an anesthetic (nitrous oxid) is of great value. These patients are often promptly cured by the manipulations of a "bone-setter" or osteopath.

Ankylosis.—Fixation or stiffness of a joint: *False ankylosis* referring to fixation by extra-articular, *true ankylosis* to fixation by intra-articular lesions. *False ankylosis* is due to traction or fixation by muscles, tendons, skin, other soft tissues; to bony outgrowths; or to a long-continued abnormal position, as follows lesions of nerves.

True ankylosis may be: 1. *Fibrous* with partial fixation, active movement causing pain. This occurs from (a) *synovitis* due to tuberculosis, gonorrhea, or rheumatism; (b) *traumatism;* or (c) *arthritis.*

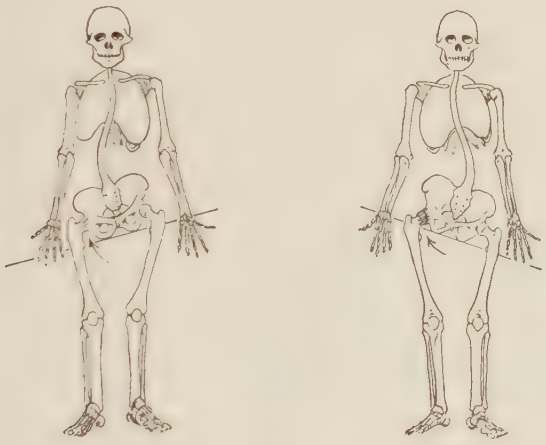
2. *Bony ankylosis* follows complete destruction of the articular cartilage and bony union. It occurs from suppurative arthritis, or chronic tuberculous arthritis of children. There is no movement and the joint is not painful.

Treatment.—That directed to the primary disease. If the joint is affected by a subacute inflammation, tuberculosis or syphilitic disease, mobilization should not be attempted.

Fibrous ankylosis, especially of traumatic origin or where the causal infection has long since disappeared, is improved by forcible separation of ad-

hesions. The restoration of free movement by manipulation under an anesthetic may be curative. The secondary reaction may be severe, and should be treated by cold or sedative applications, as for an acute arthritis, followed later by massage and passive movements. In the smaller joints, particularly, malposition can be best overcome by continuous elastic traction, as by a banjo splint. Tuberculous ankylosis with marked deformity may likewise be corrected by rest in bed and graduated weight or elastic extension.

Juxta-articular nodules (*nodules of Lutz*) occur in the tropics: Deep-lying masses of fibroconnective tissue with normal overlying skin are found over the trochanter, lateral malleolus, tibial tuberosity, head of fibula, dorsal aspect of acromion and sacrum, coccyx, and ribs. Slowly growing fibrous masses are formed, which may persist, spontaneously absorb, or suppurate, with the formation of an ulcer. Wassermann reaction is often positive. The condition may be due to a mycosis or yaws.



a *b*

Fig. 197.—*a*, Ankylosis in abduction producing an apparent lengthening of the affected leg. *b*, Ankylosis in adduction producing an apparent lengthening of the opposite leg. Compensation is produced by tilting the pelvis and a lateral curvature of the spine.

Treatment.—Iodids, arsenicals as in syphilis; or surgical excision, if persistent.

Tumors and **cysts** rarely grow from the synovial membrane. Enchondroma may grow from the synovial membrane. Cysts are usually the distention of adjacent bursa (*Baker's cyst*), and may be ignored or excised. In sarcoma the synovial fluid may be blood-stained.

Operations Upon Joints.—1. *Arthrotomy* or incision into a joint is used to give access to the joint or provide drainage. (a) *Shoulder-joint:* Anterior, nearly vertical incision along the edge of the deltoid; if sufficient drainage is not obtained, a posterior incision is also made. (b) *Elbow-joint:* Lateral incisions are made to either side of the olecranon. (c) *Wrist:* Dorsal incisions between the tendons. (d) *Hip-joint:* An anterior, or an anterior and posterior incision. (e) *Knee-joint:* Lateral incisions at the sides of the patella, or one or two incisions lateral to the popliteal space. With extreme infection threatening life, the patella may be divided transversely, the joint flexed, packed with iodo-

form gauze, and left freely open, wet dressings being continuously applied. As the infection subsides, the leg is gradually extended. (f) *Ankle-joint* is difficult to drain without excision of the talus.

2. *Arthrectomy*, or excision of the joint, is used to provide mobility, facilitate drainage, or to remove foci of disease. To provide movement, most useful with the elbow and shoulder, the structures of the joint are freely excised, and passive movement started the second week.

3. *Osteotomy*.—The bone may be divided distally to the articulation to restore movement.

4. *Arthrodesis*, the operative production of a bony ankylosis, is used for the correction of faulty positions with bony ankylosis, or for painful or tuberculous fibrous ankylosis. The bone-ends are excised, apposed, and fixed in the desired position, at times with the aid of bone-graft or other locking device, and held until firm bony union has taken place.

5. *Arthroplasty* (Helferich-Murphy).—The formation of an artificial joint has a limited field of usefulness. It is difficult to secure stability with free motion, the joint being either stiff and strong or insecure and freely movable.

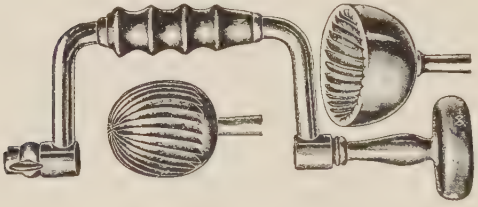


Fig. 198.—Murphy's reamer and mill for contouring the acetabulum and head of femur in arthroplasty of the hip.

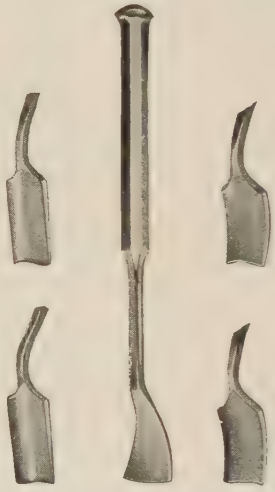


Fig. 199.—Putti's sculptural chisels used for contouring bone.

With the shoulder, the tubercles should be retained, if possible, to preserve the rotatory function. At the elbow, the method is especially useful. Arthroplasty of the hip-joint is moderately successful. Arthroplasty of the knee-joint is particularly difficult, and often does not improve the patient's condition. A laboring man is often better off with a strong, ankylosed joint (particularly of the shoulder or elbow) in a position of optimum function, than after an arthroplasty. A rigid knee in a straight or slightly flexed position is strong, serviceable, and painless, and, although it causes the patient to limp, it is usually more satisfactory than the knee after an arthroplasty. Similarly, bony ankylosis of the hip-joint in good position does not prevent locomotion, the patient moving the leg by tilting the hip, a condition preferable to a movable painful joint.

Operative methods of arthroplasty consist in resecting and contouring the articular surfaces, lining the joint with a free or attached flap of aponeurosis or fascia, with closure of the overlying ligamentous structures and skin.

Joint transplantation has been used in a few instances by Lexer and others; usually the knee-joint has been transplanted from a recently amputated leg. The method is of limited value.

After *arthrodesis* immobilization should be continued for two to six months, or until the consolidation is firm. With *arthroplasty*, graded movements should start after the second week, avoiding tissue reactions shown by excessive hyperemia or inflammation. After stripping operations, immobilization should be continued for two to four months.

After *osteosynthesis*, fixation is continued for from three to six months, being longer for the larger weight-bearing bones.

Capsulorrhaphy, resection, plication, and suture of the capsule of joints is used for relaxation in habitual dislocation, particularly of the shoulder-joint.

Special Operations.—*Arthrotomy of the Knee.*—Anterior median incision, with vertical division of the patella, gives an excellent exposure. For excision or arthrodesis a semilunar or U-shaped incision, with transverse division of the patella or the patellar ligament, is used. The medial J-shaped incision of Kocher, with displacement of the patella laterally, gives a fairly good exposure.

Arthrotomy of the Shoulder-joint.—The anterior incision begins 2 cm. below the acromion and runs downward parallel to the deltoid. The posterior incision begins 2 cm. posterior to the tip of the acromion and runs downward parallel to and 2 cm. from the posterior border of the deltoid. The incisions are carried through the skin and fat for 7 or 8 cm., the deltoid fibers are separated by blunt dissection, and the fat overlying the synovial membrane opened.

Arthrotomy of the Hip-joint.—*Anterior incision:* This begins 2 cm. below the anterior superior spine, extending downward between the sartorius and tensor fasciæ latæ, along the lateral border of the sartorius; the rectus being retracted mediad, and the tensor fasciæ latæ laterad, and the capsule opened parallel to its fibers.

CHAPTER XVII

DISLOCATIONS

Definitions.—*Dislocation* (*luxation*) is a displacement characterized by the abnormal relationship of the articular surfaces of a joint.

Sprain is a self-reduced dislocation. It is a partial displacement, instantaneously and spontaneously reduced.

Complete dislocation (*total dislocation*) is one in which contact between the articular surfaces has been lost, the articular surfaces being completely separated, or touching only at the edges. With a ball-and-socket joint, the center of the globular head is displaced beyond the rim of the socket.

Incomplete dislocation (*partial luxation* or *subluxation*) is an abnormal displacement of the articular surfaces with maintenance of partial contact.

Diastasis is a subluxation, in which the separation occurs only in a plane perpendicular to that of the articular surface. It occurs from muscular paralysis and relaxation, in the "subluxation" of the head of the radius, "pulled elbow" of children, and in the tibiofibular separation of Pott's fracture.

Complicated dislocation has associated serious or unusual injury to adjacent tissues—such as fracture, rupture of the main artery of the limb, or injury to important nerves.

Compound dislocation is one in which a communication between the joint and external air has been produced by injury to the soft parts.

Primitive dislocation is one in which the parts occupy the relation produced by the injury.

Consecutive dislocation indicates that the parts occupy a position different from the displacement originally produced, due to manipulation, movement, or other secondary force.

Dislocations are also classified as *recent* or *old*.

Bilateral dislocations are symmetrical dislocations occurring on both sides of the body.

Double dislocations involve both ends of the same bone.

Nomenclature.—Usually the distal member of the joint is given as the dislocated part, an exception being the so-called "dislocation of the outer end of the clavicle" (*acromioclavicular joint*).

Direction of the dislocation indicates that taken by the dislocated or distal bone; thus, a backward dislocation of the humerus means that the head of the humerus has been dislocated posterior to the glenoid cavity. Often the name of the injured joint is given to the dislocation, the direction being that of the distal bone, as *posterior dislocation of the knee* or *anterior dislocation of the elbow*. The dislocation may be named from the new anatomic relation of the distal bone, as *subcoracoid dislocation of the shoulder* or *iliac dislocation of the hip*.

Typical dislocations are those in which the attitude or deformity of the limb is characteristic; *atypical* are those in which, owing to the laceration of

some opposing structure, the characteristic position is not present. Atypical positions occur in dislocation of the hip with rupture of the Y-ligament.

Pathology.—In joints relaxed by paralysis or effusion (and with the jaw), dislocation habitually takes place without laceration of the capsule. In other cases, except with voluntary dislocations, the capsule is torn. In enarthrodial joints, the rent is on the side toward which the round head of the distal bone is displaced. In other joints, any or all of the ligaments may be torn. The firmer bands, instead of giving way themselves, may strip up the periosteum or tear away the bony prominences to which they are attached. The bones may also be broken by impact on each other; thus, fracture of the olecranon occurs in anterior dislocation of the elbow; and a mutual bruising of the head of the humerus and shattering of the rim of the glenoid cavity may occur in dislocations of the shoulder.

In *old, unreduced dislocations* the lacerated connective tissue about the head of a bone becomes thickened, and forms a pseudocapsule; while the periosteum, on which the head of the bone now rests, is stimulated and throws out a ridge of bone so as to form a new articular cavity, sometimes lined with fibrocartilage. The muscles and ligaments shrink or elongate to adapt themselves to their changed circumstances and, thus, a comparatively useful new joint may be formed. The old joint cavity is obliterated by adhesions of the capsule and by filling with granulation tissue.

Etiology.—1. **Anatomic.**—(a) *Anatomic and Functional:* Shallow articular cups, a loose capsule, and weak ligaments permitting wide range of movement (as in shoulder and jaw) favor dislocation. Restricted movement, from the interlocking of bones and from strong short ligaments, reduces the tendency to dislocation. Except in the cervical region, dislocation of the spine without fracture is uncommon. Dislocations of the hip are much less common than of the shoulder, of the carpus and tarsus less common than of the elbow and patella. The shoulder is more frequently dislocated than any other joint, while 90 per cent. of all dislocations involve the upper extremity.

(b) *Age: Intra-uterine dislocation* occurs from failure of a joint to properly develop, from disease of the joint, ligaments or muscles, or from trauma. *Congenital dislocations* are usually produced by violence during delivery. Dislocations from injury are rare before the age of ten, and usually occur in middle life.

(c) *Sex:* Dislocations are more common in men than in women, due to the more strenuous form of life of the former. Certain subluxations, as sacro-iliac strain, occur more frequently in women, due to the greater ligamentous relaxation.

2. **Trauma.**—(a) *Indirect violence*—the force being applied at a distance from the joint—is the most common cause of dislocation. (b) *Direct violence*—the force being applied directly to a joint. (c) *Muscular action*, as in yawning or in pitching a ball.

Some persons can voluntarily produce subluxations, especially of the first phalanx of the thumb.

3. **Disease.**—*Pathologic dislocations* are those which occur spontaneously or from slight force. They are due to disease of the joint, such as tuberculosis,

osteo-arthritis, Charcot's disease; or to the wasting and weakening of muscles and ligaments, in paralysis and during prolonged fevers (as typhoid).

Symptoms.—1. **Deformity** is always present, and is shown upon inspection and palpation by: (a) *change in contour;* the joint cavity is empty, the head of the bone occupying a new position; (b) *change of relationship* of normal bony prominences about the joint; (c) *change in measurements* (shortening or lengthening) as compared with the opposite joint; including lengths and circumferences, and abnormal changes in measurement when different positions (as abduction or adduction) are assumed. The new position of the head of the bone makes a new and abnormal center for the movements of the joint, and there is, therefore, usually a change in the axis of the dislocated bone.

2. **Reduced Function** (*Preternatural Immobility*).—Motion in the joint is restricted by the new position of the dislocated bone, and by the influence of untorn ligaments or bony prominences.

3. **Pain.**—*Primary pain* is caused by the laceration of the tissues at the moment of dislocation, and soon subsides. *Persistent pain* is due to pressure on nerves, stretching of untorn ligaments, associated fracture, or other complication, and can only be relieved by the removal of the cause. Evidence of injury, as shown by local swelling, tenderness, and discoloration, is not invariably present.

Symptoms of Old, Unreduced Dislocations.—Abnormal contour and attitude, as well as restriction of motion, will persist as long as the dislocation remains unreduced; but, as the parts adapt themselves to altered conditions, a new socket forms and the disability becomes progressively less until, at times, the functions of the limb can be fairly well performed. Several conditions may interfere with restoration of function, however: Excessive production of cicatricial tissue may limit or abolish the motions of a joint; the head of the bone may be progressively displaced, and the disability become correspondingly greater; or an intractable neuralgia or edema result from pressure on adjoining nerves or vessels.

Diagnosis.—Dislocation is indicated by: 1. **Preternatural immobility** or abnormal restriction of movement, in contrast with the abnormal point of movement or preternatural mobility found in fracture.

2. **Abnormal relation of the bony prominences** of a joint.

3. **Abnormal relation of the articular surfaces,** as shown by the position of the limb, or by palpation and roentgenogram.

4. **Deformity,** including the change in contour of the joint and the peculiar position in which the limb is held.

5. **Reduced Function.**—The dislocated elbow cannot be flexed or extended. The dislocated jaw cannot be closed.

6. **Changes in Mensuration.**—Shortening or lengthening of the limb, which may vary with the position assumed; alterations in the diameter and circumference of the joint, not due to local swelling, give important evidence of dislocation.

In typical dislocations, the attitude of the limb and the limitation of motion usually first attract the surgeon's attention to the true nature of the injury. Conclusive evidence of a dislocation is the recognized presence of the head of

the dislocated bone in an abnormal position, or the absence of the head of the bone from its normal situation. With the fingers or knee, the head of the bone may be seen; elsewhere it may be felt or, in some instances, the diagnosis is made by finding an indefinite mass which partakes of the motions imparted to the bone.

Differential Diagnosis.—The differentiation of a simple dislocation from fracture at or near the articular surfaces is often difficult without roentgenograms. If the fracture is through the neck of the bone (without impaction), the dislocated head will not move with motions imparted to the shaft of the bone, but will give bony crepitus, unless soft parts are interposed. Soft or fibrous crepitus may also be elicited during the manipulation of a dislocated part. If the fracture consists simply of the splintering of an articular edge or the tearing off of a tuberosity, the fragment may be pushed or drawn away, and produce no symptoms except, perhaps, a weakness in the joint, a lack of certain motions, or a tendency to recurrence of the apparent dislocation, for which we can only assign a fracture as the probable cause.

In fractures, abnormal mobility is created. In dislocations, mobility is decreased in some directions, but is not infrequently increased in others; indeed, with sufficient laceration of all the soft parts it may be increased in all directions. In all cases of doubt, a dislocation should be differentiated from fracture, a contusion, or sprain by Roentgen-ray examination.

Complications.—Fractures, such as that of the anatomic neck of the humerus, may prove insurmountable obstacles to reduction. External wounds, especially if they compound the dislocation, may prove serious complications. Hematoma, traumatic aneurysm, necrosis, gangrene, and fatal hemorrhage result from rupture of adjacent blood-vessels. The rupture of nerves causes paralysis and anesthesia. Pressure upon vessels or nerves by the displaced bone or fibrous tissue causes edema, pain, and paralysis. The viscera are rarely injured, unless by some other associated trauma.

Prognosis.—Reduction is usually followed by repair of the damage done and, within a few weeks, the joint is as useful as ever. Occasionally, however, a permanent laxity of the capsule remains (especially with the shoulder), which allows the dislocation to recur on more or less slight provocation (*habitual* or *recurrent dislocation*). Without evidence of unusual injury to the nerves or joint at the time of accident, a dislocation may be the starting-point of an intractable neuralgia or chronic arthritis. The cicatricial tissue formed may tear in attempts at reduction, with serious injury to vessels or nerves. In some unreduced old dislocations the new joint becomes fairly useful, although it often causes much trouble. Complete relief by operation is not always possible, especially in adults and in elderly, rheumatic patients.

Obstacles to reduction include: (1) Muscular spasm; (2) interposition of ligaments, muscles, or portions of the capsule; (3) rupture of ligaments giving a necessary fulcrum for reduction; (4) associated fracture.

Treatment.—A recent dislocation should be immediately reduced, unless great inflammatory reaction, swelling, or shock renders the infliction of pain or the use of anesthetics inadvisable.

Anesthesia is important to produce relaxation of muscles and to relieve

pain. Reduction may be effected in "primary" anesthesia, but often complete muscular relaxation is desirable.

Ether is safer than chloroform. *Nitrous oxid* is less useful than the more relaxing general anesthetics. *Spinal anesthesia* gives excellent relaxation for dislocations below the level of the diaphragm. *Local anesthesia*, produced by the distention of the capsule with a ½ to 1 per cent. procain solution, will at times abolish reflex spasm and permit of a nearly painless reduction.

Gunn's Law.—The limb must be placed in the same position as at the time of injury, and force exerted on the displaced bone in the reverse direction to that which caused the dislocation.

Reduction.—Before reduction, any associated palsy or complication should be carefully noted (may otherwise later be attributed to the treatment).

Methods of reduction are: 1. *Posture* (Stimson).—The part is placed in such position that the head of bone is opposite the rent in the capsule when, with the necessary relaxation of muscles, spontaneous reduction may occur.

2. *Manipulation.*—By a series of movements the head of the bone is brought opposite the tear in the capsule, the opening is enlarged by relaxation of its sides, and the head of the bone slipped into place by leverage on the untorn portions of the capsule and ligaments, aided, if need be, by traction on the limb and pressure on the head of the bone.

3. *Extension* and *counterextension*, with associated manipulation or pressure on the head of the bone. Traction is made by hand, by pulleys, or other devices. Violent unskilled attempts at reduction have caused fracture of the bone; rupture of vessels, leading to hemorrhage, gangrene, or aneurysm; injury to large nerves, and even complete avulsion of a limb.

In old dislocations, with contractures, prolonged preliminary traction may be used to gradually stretch the shortened tissues, and to permit reduction with the least danger to vessels and nerves. Many accidents have followed manipulation in these cases. Reduction after three months is rarely possible without an open operation. With the elbow, one month is usually the time limit.

Dislocation with Associated Fracture.—Postural or gentle manipulative methods should first be tried under anesthesia. If unsuccessful, the part should be supported in a position of comfort with sufficient traction to relieve pressure, and reduction accomplished eight or ten days later by an open operation.

After-treatment.—After reduction the joint is supported, immobilized for a few days, and movements of the joint limited for six weeks. For certain dislocations (as of the clavicle or ilium) continued support for several months is required to ensure retention. For most joints, gentle passive motion should be started in two or three days to prevent adhesions and maintain function.

Habitual dislocations at the inner end of the clavicle have been cured by periarticular injections of alcohol (Stimson), and at the shoulder by injections of tincture of iodin. But this method of producing adhesions has such risks of subsequent ankylosis, that for the more important joints it is advisable to operate, if the tendency cannot be overcome by the prolonged wearing of immobilizing apparatus. The lax portion of the capsule may be excised, lapped, or reefed; muscles or tendons sutured; or an osteoplastic operation performed to deepen or reinforce the bony socket.

Open or compound dislocations should be treated by immediate disinfection and closure, as with compound fractures. Drains, if used, should not enter the synovial cavity.

In the event of purulent infection, *Willems' treatment* by active movement is of great value. Free drainage is obtained, but no foreign body introduced into the synovial sac. Weight-and-pulley extension is applied, and the patient made to passively and actively move the joint freely every two hours. The movement, at first painful, soon becomes practically painless. The pus is forced from the synovial cavity by the movements, and the patient recovers with a movable joint. Very free use of the joint is insisted upon after the third week.

Gunshot Wounds of Joints.—The conclusions reached at the Interallied Surgical Conference are as follows:

1. At the dressing station wounded joints should be immobilized with great care in an appropriate apparatus.

2. At the clearing station all injured joints in which the wound is extensive, the joint tissues lacerated or the missile retained, should be operated upon, if possible, within the first six or eight hours, especially when a fracture is present. The French surgeons extend this rule to all cases, except certain bullet wounds with a punctiform orifice and without fracture.

3. Roentgenoscopy is indispensable in every case.

4. The operation should include a wide aseptic arthrotomy, with excision of the wound track, complete exploration of the joint, systematic removal of foreign bodies and splinters, and cleaning and curetting of the lesion in the bone. This should be followed either by complete closure or by closure of the capsule with superficial drainage. A compressing dressing should be applied.

5. Resection, typical or atypical, should only be practised when there is considerable damage to the bone. In the knee the operation should be primary, whereas, in the elbow and shoulder a secondary operation is preferable.

6. In severe suppurative arthritis the first measure should be a wide arthrotomy, with complete immobilization and progressive disinfection of the wound. If this treatment fails, then resection should be practised with, at first, separation of the articular surfaces by extension. In every grave case immediate resection is required.

Prevention of Complications.—In the treatment of dislocations it is important to prevent secondary complications: Bed-sores; pressure sores; interference with the circulation from tight splints or bandages, which may lead to muscular degeneration (Volkmann's contracture) and the production of static deformities, such as drop-toe or pointed toe.

Optimum Positions for Ankylosis.—Much disability may be saved by keeping joints that may become ankylosed in the position of greatest usefulness, as indicated on page 264.

SPECIAL DISLOCATIONS

Lower Jaw.—Varieties: The lower jaw is usually dislocated forward; the displacement being, in most cases, bilateral. Rarely the dislocation is backward or upward (central dislocation), the condyle entering the cranial cavity. In the forward dislocation the condyles pass on to the articular tubercle or, beyond it, into the zygomatic fossa. *Subluxation* is a unilateral and often a repeated displacement, usually spontaneously reduced. *Clacking jaw* is a mild form, with audible noise from slipping of the articular cartilage as the patient masticates or talks.

Etiology.—Dislocation may be caused by yawning, vomiting, introduction of a mouth-gag, the separation of the jaws in dental operations, and, sometimes,

by blows upon the chin. The dislocation results from contraction of the external pterygoids aided, when the mouth is widely opened, by the temporal and masseter muscles.

Symptoms.—The mouth cannot be shut, the lower jaw protrudes forward, and, if unilateral, the chin is displaced toward the opposite side. A depression is present in front of the ear over the glenoid fossa, and the condyle may be felt in the new situation over or in front of the articular tubercle.

Treatment.—Pressure is made downward and backward on the lower molars by the padded thumbs, while the fingers elevate the chin. To prevent recurrence a Barton or Gibson bandage should be worn for two weeks, and the patient cautioned against widely opening the mouth for several months. For recurrent dislocations and subluxations, fibrous deposits about the condyle may be stimulated by the injection of 5 per cent. solution of phenol or 60 per cent. alcohol, care being taken to avoid the upper branches of the facial nerve. Excision of the condyle is rarely necessary.

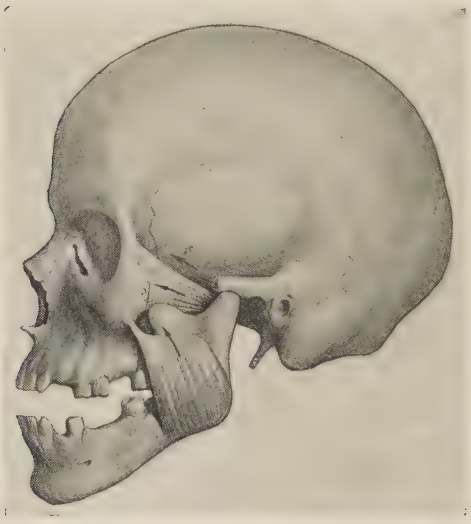


Fig. 200.—Anterior dislocation of the mandible showing the action of the pterygoideus externus and masseter muscles in fixing the deformity.

Clavicle.—1. **Sternal end:** The sternal end of the clavicle may be dislocated *forward*, *upward*, or *backward*.

(a) *Forward dislocation* is caused by the shoulder being pushed or pulled violently backward. The bone lies in front of the manubrium sterni. (b) *Backward dislocation* is rare, and results from direct violence or from forcing the shoulder forward and inward. The head of the bone lies behind the sternum, a depression exists over the joint, and the acromion is nearer the midline. Movements of the head and neck are limited, and dyspnea, dysphagia, or congestion may result from pressure upon the trachea, esophagus, and vessels. (c) *Upward dislocation* is very rare, and is caused by violent depression of the shoulder. The head of the bone is in a higher position, and may press upon the esophagus and trachea, while the shoulder falls down and in.

Treatment.—Reduction is obtained by manipulating the displaced end of the clavicle, while the shoulders are drawn back and the knee presses between the scapulæ. In forward dislocation reduction is easy, but retention may be difficult. In backward dislocation, to overcome pressure symptoms, the head of the bone may have to be excised, wired, or sutured in position. For upward dislocation a pad is placed in the axilla and the shoulder raised and pressed backward. A figure-of-8 bandage is used about the shoulder in all cases, with appropriate pads and strapping; the bandage being continued for four or five weeks. Injection of alcohol (Stimson) or 5 per cent. phenol about the joint may be useful to increase the deposit of fibrous tissue and fixation.

2. **Acromial end of the clavicle** is usually dislocated upward; dislocation downward rarely occurs; in the *former* the outer end of the clavicle is prominent, the scapula slipping downward and inward; in the *latter* there is depression over the joint, with prominence of the acromion. The displacement results from falls or blows upon the shoulder, the base of the coracoid acting as a fulcrum (G. G. Davis). Reduction is easy, but difficult to maintain. The bandage used should be of the Velpeau type, being carried over the shoulder and under the flexed elbow, and continued for three or more weeks.

Unreduced dislocation of outer end of clavicle usually gives few symptoms, but should pain, disability, or stiffness result, open fixation may be performed.

Dislocation of the lower end of the scapula (*scapula alata, winged scapula*) is not a dislocation of the lower end of the bone from beneath the latissimus dorsi, but is a condition following paralysis of the serratus anterior muscle, caused by injury or disease involving the long thoracic nerve.

Fig. 201.—Subcoracoid dislocation of the humerus. (Roentgenogram by Dr. G. C. Bird.)

Dislocation of the shoulder is the most frequent of all dislocations (50 per cent.), due to the shallowness of the glenoid fossa, the great range of movement, the disproportion in size between the head of the humerus and the glenoid cavity, and the laxity of the capsular ligament.

Etiology.—Dislocation of the shoulder is most common in adult males; the proportion of females increases with age. Dislocation results from falls on the outstretched hand or elbow (the humerus being displaced downward or backward in abduction) or, especially where previous dislocation has occurred, from violent muscular exertion. The head of the bone tears through the lower and mesial part of the capsule, which is the weakest part, entering the axilla in front of the triceps, from which it is displaced forward or backward. From the *primary subglenoid position*, the *final positions* assumed by the head of the bone are:

1. *Subcoracoid.*—The head lies below the coracoid process upon the neck of the scapula, the tendon of the subscapularis being torn and stretched over the neck of the humerus. The supraspinatus, infraspinatus, and teres minor are tightly stretched or torn. Three-fourths of the dislocations of the shoulder are subcoracoid.

2. *Subclavicular* is rare, and represents a forward and medial movement of the head from the subcoracoid position. The great tuberosity of the coracoid process is fractured, or the attached muscles torn. The humeral head lies below the clavicle.

3. *Subglenoid.*—Rare. The head of the bone lies on the axillary border of the scapula, below the glenoid cavity; the muscles attached to the tuberosity are torn, and the axillary vessels compressed.

4. *Subspinous.*—A posterior dislocation in which the head rests on the posterior aspect of the neck of the scapula, the subscapularis muscle being torn. It may follow extreme direct violence.

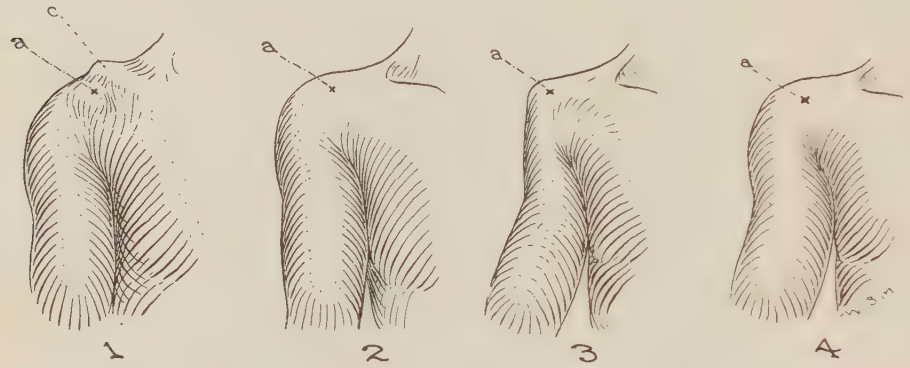


Fig. 202.—Contour of the shoulder in: (1) Upward dislocation of acromial end of clavicle. (2) Normal shoulder. (3) Subcoracoid dislocation. (4) Fracture of the surgical neck of the humerus. *a*, Coracoid process of scapula; *c*, acromial end of clavicle.

5. *Supracoracoid.*—A very rare form in which the acromion and, possibly, the coracoid are fractured; the head of the bone tearing through the upper part of the capsule, and coming to rest above the coracoid process.

6. *Luxatio erecta* is a rare form, in which the head of the bone lies below the glenoid cavity, with the arm pointing upward along the side of the head.

The subclavicular, subcoracoid, and subspinous dislocations may be primary, the head of the bone passing directly to its new situation without first entering the axilla.

Symptoms are: Pain, swelling, rigidity, ecchymosis, and loss of function; flattening of the shoulder and prominence of the acromial process, so that a straight edge may touch the acromion and lateral epicondyle at the same time. The head of the bone is felt in an abnormal position, the elbow is displaced from the side and cannot touch the chest wall, while the hand is on the opposite shoulder (*Dugas' sign*, 1856). This sign may be absent in certain subcoracoid dislocations. There is an increase in the vertical measurement around the axilla (*Callaway's sign*), and a lowering of the axillary folds (*Bryant's sign*).

The distance from the acromion to the lateral epicondyle is usually unaltered, or it may be shortened or lengthened.

With a *subglenoid* dislocation there is about 2.5 cm. of lengthening. In the *subcoracoid* the head is felt below the coracoid and the outer end of the clavicle, the elbow is directed outward and backward, and there is little or no shortening. In the *subclavicular* the head is felt below the middle of the clavicle, shortening is present, and the elbow is carried far from the side. In the *subglenoid* the head is felt in the axilla, with evidence of pressure upon the vessels and nerves, marked lengthening of the arm, and flexion of the elbow from tension on the biceps. In the *subspinous* the head of the bone is felt behind and below the acromion, under the infraspinatus muscle; the elbow is displaced forward, and the arm rotated inward. In *subluxation* of the shoulder the head passes forward from rupture or displacement of the long head of the biceps.

Treatment.—Reduction is effected by posture, manipulation, extension, and counterextension, alone or combined.

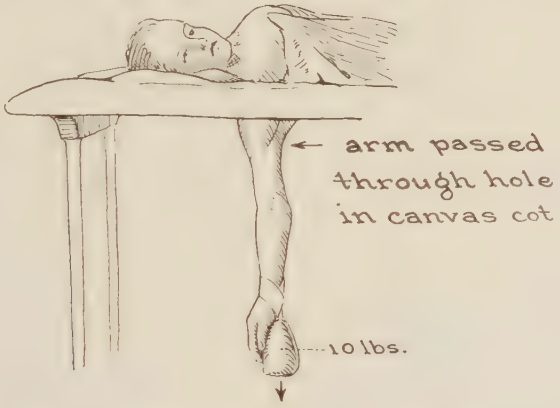


Fig. 203.—Stimson's postural method of reducing a dislocation of the shoulder.

1. *Postural Method* (Stimson, 1900): The patient lies on the affected side on a canvas cot, the arm projecting through a hole in the canvas, a 4.5- to 7-kilo weight being tied to the wrist. In about six minutes the contracted muscles relax, the head is drawn close to the glenoid, and the dislocation is reduced. This is a simple and safe method, worthy of more general use.

2. *Manipulation* (*Kocher's method*, 1870): The elbow is flexed to a right angle and pressed against the side, while the forearm is carried outward so as to produce external rotation of the humerus and to relax the external rotators. Maintaining external rotation, the elbow, while being raised, is adducted to the midline, so as to relax the upper margin of the rent in the capsule, while the lower part is kept tense through external rotation. To make the head of the humerus slip into the opening in the capsule the arm is now rotated inward, so that the hand is placed on the opposite shoulder, and finally the elbow is lowered.

(a) In the first movement of Kocher's method the rent in the lower part of the capsule is made to gap, and the head of the humerus rolls away from the midline until it lies opposite the opening. Rotation takes place about a fixed point, and the anatomic neck of the humerus contacts with the anterior lip

of the glenoid cavity, maintaining external rotation. (b) The elbow is next carried forward, upward, and toward the midline, the humerus acting as the long arm of the lever, on the fulcrum furnished by muscles inserted in the region

Fig. 204.—Kocher's method of reducing a subcoracoid dislocation of the humerous, first maneuver: Fixation of elbow against chest, external rotation of arm.

of the surgical neck. The head, which forms the short arm of the lever, is carried backward, downward, and laterally toward the socket (c) The humerus is now rotated toward the midline by carrying the hand across the chest to the

Fig. 205.—Kocher's method of reducing a subcoracoid dislocation of the humerus: The elbow is elevated and the external rotation of the arm continued.

Fig. 206.—Kocher's method of reducing a subcoracoid dislocation of the humerus: Elevation of the elbow with internal rotation of the arm.

opposite shoulder. The anatomic neck is thus disengaged from the edge of the glenoid, and the head is pulled into the socket by the tension of the surrounding muscles. Attempted by the novice without anesthesia Kocher's method will often fail to accomplish reduction. In the after-treatment abduction particularly should be avoided.

H. H. Smith's method (1858) resembles Kocher's, except that the first position is omitted.

3. *Reduction by Extension* (Malgaigne, 1855): The patient lies on the floor on his sound side, while the surgeon makes traction on the wrist of the injured side with the arm at right angles to the body, sufficient to lift the body clear of the floor. The method is simple and frequently is effective after others have failed.

4. *Extension and Counterextension (heel-in-axilla method)*: The patient lies down, the surgeon sits on the floor beside him and places his stocking-covered heel in the patient's axilla, while he grasps the hand and wrist of the patient and makes traction and countertraction in the direction of the axis of the humerus. The heel is used as a lever, and a little rotation and secondary adduction of the arm may aid the entrance of the head into the capsule. This method, although blamed for various secondary complications, has reduced more dislocations of the shoulder than all other methods combined.

5. *Sir Astley Cooper's Method* (1822): The patient sits with the surgeon's flexed knee under his axilla, and the elbow is forced toward the patient's side over the knee.

Caution: With the methods of extension and counterextension there is danger of injury to the axillary vessels and nerves, and, before attempting reduction, the surgeon should note whether there is any evidence of nerve injury. After reduction, the shoulder should be well supported by a Velpeau bandage or a strong sling for a week or ten days.

Prognosis in dislocations of the shoulder should be guarded. The axillary nerves may be stretched or torn, with secondary paralysis or weakness of the supplied muscles, or a traumatic neuritis or secondary arthritis may follow reduction. Recurrence often results, especially if abduction movements are permitted before the repair of the capsule is complete.

Dislocation of the Shoulder, Associated with Fracture of the Upper End of the Humerus.—In this combined injury the dislocation is usually subcoracoid, the fracture involving the surgical neck, the anatomic neck, or the great tuberosity; the injury being due to direct violence by a fall or blow upon the shoulder or a "run-over" accident. Upon examination the glenoid cavity is found empty, and rotary movements of the humerus are not communicated to the displaced head of the bone. The deformity is easily reduced, but recurs as soon as support is withdrawn. The patient should be anesthetized, and Malgaigne's method or extension in a hyperabducted vertical position made, while manipulation is used to force the head into the socket. Care should be taken not to use the lower fragment as a lever. If extension and manipulation fail, operation (using McBurney's hook, Kocher's or Murphy's bone-skid, or Arbuthnot Lane's lever) to replace the head should be considered, after allowing a delay of eight days for the tissues to recover from the primary trauma. If the head of the bone cannot be reduced, it may be excised. In the aged or debilitated an open operation may be unwise.

Long-standing Dislocations of the Shoulder.—Within four weeks from the time of injury reduction should not be difficult. Between four and nine weeks reduction is usually possible; beyond nine weeks reduction is exceptional with-

out an open operation. Operation is not advised if the false joint is functional and painless, or if the patient is senile and a poor operative risk. The operation should consist of an open reduction or, if this is not possible, an excision of the head, or an osteotomy is used. *Voluntary subluxation* of the shoulder is possible in rare cases.

Recurrent dislocations usually occur in young women. The capsule of the shoulder-joint is supported above and posteriorly by the tendons of the supraspinatus and the teres minor muscles. The capsule is weakest below and anteriorly between the subscapularis and the teres major tendons. With the arm abducted, and the neck of the humerus in contact with the tip of the acromion, further abduction forces the head against the lower weaker portion of the capsule. Dislocation is then readily produced in a relaxed or unconscious person. The hyperabduction which produces the redislocation occurs in swimming, throwing a ball, dancing, gymnastic exercise, and in arranging the hair.

Fig. 207.—Backward dislocation of both bones of the elbow: *a*, Prominence of olecranon; *b*, prominence of head of radius; *c*, lateral epicondyle.

Treatment.—By a belt around the thorax, connected to another around the arm, abduction may be restricted. Operation is frequently desirable. *T. T. Thomas' incision* is along the anterior border of the coracobrachialis which, with the biceps and pectoralis major, is retracted laterad, the axillary vessels and nerves being drawn mediad. The subscapularis is partially divided, avoiding the axillary nerve and posterior circumflex vessels. The capsule is then incised, and the edges reefed or lapped; or, if the capsule is very weak, it may be reinforced by a graft from the fascia lata.

Snapping shoulder (from the head slipping beneath the contracted deltoid, or the tubercle catching between the short tendon of the triceps and the coracobrachialis) occurs in the young and disappears in later life, requiring no treatment.

Sprain of the shoulder-joint is comparatively rare, on account of the wide range of movement of the joint. There is tenderness and swelling, the chief point of tenderness being over the anterior part, just below the acromion.

Contusion of the shoulder is very common, as is subacromial bursitis. If the cords of the brachial plexus are stretched or bruised, severe secondary neuralgic pains, palsy, or muscular atrophy may follow.

Dislocations of the Elbow.—Dislocation of the elbow-joint may involve one or both bones of the forearm, and may be *complete* or *incomplete*, and: (1) *Backward*, the most common; (2) *forward;* (3) *lateral* or *outward;* (4) *medial* or *inward;* (5) *divergent*—one bone forward, the other backward. Backward dislocation of both bones is a frequent dislocation in children.

Etiology.—Dislocation of the elbow is caused: (1) *Indirectly*, by a fall on

the outstretched hand from hyperextension of the joint with abduction or a twist of the forearm; (2) *directly*, by a fall upon the elbow or blow on the back of the humerus.

Lesions.—All the ligaments of the elbow (ulnar collateral, radial collateral, and the articular capsule), except the annular, are torn or stretched. Either epicondyle may be fractured and carried back with the forearm. The radius and ulna pass backward, the coronoid process often being broken. The lower end of the humerus lies in the flexure of the joint, with the biceps tendon tightly stretched over it. If the coronoid process is not broken, the tendon of the brachialis may be ruptured, and the ulnar nerve may be stretched or torn. Frequently the bones of the forearm are displaced medially as well as backward. After this dislocation bony outgrowth or *myositis ossificans* often follows from stripping of periosteum, especially near the insertion of the brachialis, and may interfere with the movements of the joint. After six months the new growth of bone may be partially absorbed. If it persists and produces disability or pressure upon the median nerve, it should be removed.

Fig. 208.—Showing mechanism of lateral dislocation of elbow with fracture of medial epicondyle: *h*, Humerus; *r*, radius; *u*, ulna.

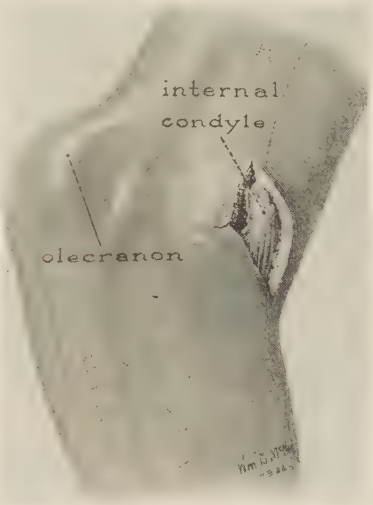


Fig. 209.—Compound lateral dislocation of the elbow with fracture of the medial epicondyle.

Symptoms.—The elbow is fixed at an angle of about 120 degrees, flexion and extension being limited. The distance from the olecranon to the epicondyles is increased, that from the acromion to the epicondyles unaltered, and that from the epicondyle to the styloid processes is reduced; the olecranon is unduly prominent, and lies below a posterior concavity.

Diagnosis is to be made from supracondylar fracture with backward displacement of the lower fragment and separation of the lower humeral epiphysis. When reduced, there is no tendency to reproduction unless the coronoid process is fractured. Often the dislocation is incomplete, the coronoid resting at the level of the trochlea, the backward projection of the olecranon being slight, and the head of the radius unduly prominent. *Forward dislocation* is rare, except as a complication of fracture of the olecranon. The forearm is lengthened, the epicondyles unduly prominent, and the olecranon obscured. It is produced by

severe force, acting from behind on the flexed elbow. If the olecranon is not broken, it may rest below the epicondyles, forming the incomplete or *first-stage dislocation;* or pass in front of them, especially if the triceps is ruptured, with complete or *second-stage dislocation.*

Treatment.—*Reduction of backward dislocation* is best carried out under an anesthetic, by flexion of the forearm over the operator's knee, placed in the bend of the elbow. The limb is first fully extended or even hyperextended to relax the triceps and free the coronoid process, with traction upon the forearm and arm. Backward pressure is then made with the knee upon the lower end of the humerus, and the joint is slowly flexed. In children, if the arm is raised to relax the biceps and the arm grasped above the elbow, the olecranon can usually

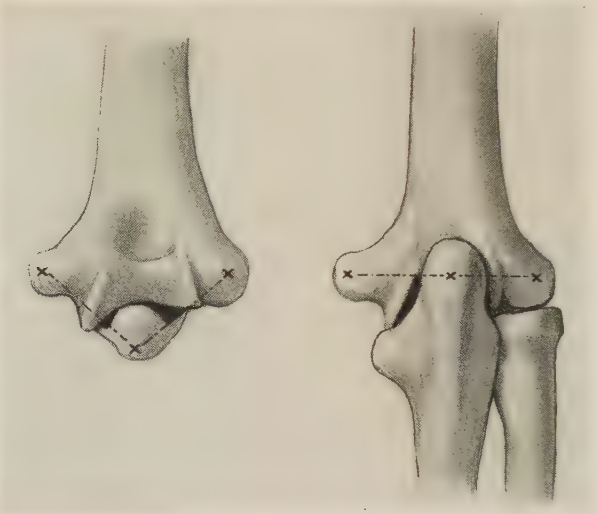


Fig. 210.—Elbow: Normal relationship of the medial and lateral epicondyle and olecranon, with the elbow flexed and extended.

be pushed down into reduction by pressure of the two thumbs. Violent manipulations by raising the periosteum increase the danger of ossification along the brachialis, and should be avoided. After reduction the arm should be held in a sling at a little less than a right angle for ten days, and graduated massage and passive movements started the second day. Nearly full movement should be attained at the end of three or four weeks.

To reduce *forward dislocations* the elbow is fully flexed, and the bones of the forearm then pushed backward and downward while the humerus is pulled forward.

Long-standing or Chronic Dislocation of the Elbow.—After four weeks the olecranon and coronoid fossæ are filled with new tissue, preventing reduction. Violent manipulation is dangerous after five or six weeks have elapsed, and should be replaced by open operative reduction, or by resection of sufficient amount of the lower end of the humerus to provide a movable joint.

Medial and Lateral Dislocations.—Those to the ulnar side are *always* incomplete; to the radial side, *usually* incomplete.

Etiology.—A fall on the outstretched hand, the forearm being strongly pronated; with forced abduction when the displacement is to the ulnar, or adduction when the displacement is to the radial side.

The *diagnosis* is evident; the position is one of flexion and pronation.

Diverging dislocation, in which the radius and ulna are separated and the strong annular ligament torn, occurs from a fall or great violence, and is very rare. The radius may be in front and the ulna back of the humerus or, very rarely, the radius lies to the radial side and the ulna to the ulnar, the humerus being interposed.

Dislocations of the ulna alone are very rare, usually backward, and associated with fracture of a process of the medial epicondyle.

Dislocation of the radius alone is common, especially when associated with fracture of the upper third of the shaft of the ulna.

Dislocations of the Head of the Radius.—Varieties: (1) Complete and forward, common; (2) backward; (3) lateral dislocation, very rare; (4) incomplete; (5) subluxation; (6) complete, with rupture of the annular (orbicular) ligament.

Dislocation of the head of the radius results from a blow on the back of the upper end of the radius, a fall on the outstretched hand, or, in children, from forcible traction on the forearm while it is in the pronated position.

Deformity.—The head passes forward and presses on the anterior edge of the capitulum, preventing complete flexion and supination of the forearm. There is the prominence of the head of the radius in the front of the elbow, a hollow below the lateral epicondyle. The limb is partly flexed and pronated, and there is slight shortening of the radial side of the forearm. Evidence of pressure upon the superficial or deep (posterior interosseous) branches of the radial nerve is not infrequent. Reduction is easy, but, owing to rupture of the annular ligament, the retention may be difficult.

Fig. 211.—Posterior dislocation of the ulna without the usual fracture of the coronoid process: *h*, Humerus; *tri*, triceps; *o*, olecranon; *e. c.*, lateral condyle; *r*, radius; *u*, ulna.

Treatment.—With traction, the elbow is flexed and extended, as pressure is made on the head of the radius to force it into position. The interposition of torn ligaments may prevent reduction, so that an open operation is necessary. A pad is placed at the front of the elbow, and the joint fixed in acute flexion for three weeks, care being taken that the radial pulse is not obliterated. Massage and cautious passive movements may be started at the end of first week. In persistent or chronic displacement, interfering with flexion of the elbow, or where there is pressure upon the radial nerve, operative reduction and repair of the annular ligament or resection of the head of the radius is indicated. Excision of the head of the radius causes little disability, and may restore full movement to the elbow.

Subluxation (*"pulled elbow," Malgaigne's luxation*) occurs in children under

four years from lifting or pulling upon the hand or forearm. The anterior part of the radial head is pulled out of or jammed into the annular ligament with a painful slip or click. The arm is held flexed and the hand pronated. All movements are painful, especially supination. The deformity is slight, although the head of the radius may be unduly prominent in front.

Reduction is usually easily produced by flexing and extending the elbow with traction, or by alternate pronation and supination. No retentive device is required, nor is recurrence usual. Simultaneous swelling of the wrist from the injury may distract attention from the elbow.

Sprain of the elbow frequently occurs from a fall on the hand or a twist of the forearm. Tenderness is chiefly over the radiohumeral joint, the radial, collateral, and annular ligaments being most frequently damaged. There is swelling and relaxation of the joint, but the bony points about the elbow maintain their normal relationship. In children, a partial separation of an epiphysis may be difficult to differentiate without a roentgenogram, which, therefore, should always be made.

Tennis-elbow results from the tearing of the muscles inserted about the elbow (especially the pronator teres) or a stretching of the fibers of the adjacent intermuscular septa.

Dislocation of the Carpal Bones.—One row of the carpal bones may be dislocated upon the other, or any individual bone displaced, usually from violent or crushing injury, or from a fall upon the extended hand. A fracture is often associated.

Forward dislocation of the carpus results from forced flexion of the wrist, such as is caused by a fall on the back of the hand or direct violence. The displaced carpus projects on the palmar surface, while there is a corresponding depression on the dorsum of the wrist. Reduction is usually easy. After reduction the hand and forearm should be supported by a molded or padded splint, with the hand in moderate dorsiflexion. Daily massage and passive movements are desirable, and the support should be continued for at least three weeks.

Anterior dislocation of the lunate (*semilunar*) **bone** is the most common dislocation of a single bone of the wrist. There is miniature silver-fork deformity from the prominence of the capitate (os magnum) posteriorly, the depression from the forward displacement of the lunate being just above. The lunate is felt under the flexor tendons of the wrist. The distance from the radial styloid to the base of the first metacarpal is lessened, the relations between the styloid processes and the radius are unaltered. The injury follows forcible dorsiflexion of the hand, and may implicate the ulnar nerve.

Reduction is made by hyperextension, and then hyperflexion, over the thumbs of an assistant pressing on the lunate (Codman and Chase), by a Thomas wrench or, after ten or more days have elapsed, by open reduction or excision.

Dislocation of the navicular bone (*carpal scaphoid*) is usually backward, and either *partial* or *complete*. It results from forced flexion of the wrist, and produces a prominence on the dorsum of the wrist. Injury to the median nerve may be associated.

Sculler's sprain is a similar displacement from rowing.

Reduction is made by direct pressure with forcible flexion and extension, or operative reduction or excision is used.

The *after-treatment* includes fomentations, massage, baking, and passive movements, avoiding those movements which produce pain.

Dislocation of the wrist may be backward or forward; both are rare, the latter very rare. Fractures about the wrist are much more common. The deformity may resemble a Colles or Smith fracture, but the relationship of the styloid processes is preserved, while the relation of the projecting carpal bones to the styloid processes is altered.

1. *Dislocation of the radiocarpal articulation* is frequently compound, and the articular edge of the radius may be fractured. It results from great violence, as a fall from a height on the palm of the dorsiflexed and abducted hand. It is differentiated from a Colles fracture in that the deformity is below the radial styloid, the hand more flexed, and the angulation more abrupt. The palm is shortened, the forearm is not shortened. The plane of the carpal bones is posterior or anterior to that of the styloid.

2. *Dislocations of the wrist* occur rarely at the inferior radio-ulnar, radiocarpal, midcarpal, intercarpal, or carpometacarpal joints. An inferior radio-ulnar dislocation may complicate a fracture of the lower end of the radius, or accompany subluxation of the head of the radius. The head of the ulna usually passes backward. In children, subluxation may follow lifting the child by the hand; in adults, forcible pronation or supination, as in wringing clothes. If from direct violence, the separation is frequently complete and compound. The lower end of the ulna is unduly prominent, with a depression on the opposite aspect of the joint. The hand is usually pronated, and movements of the wrist are restricted and painful, while flexion and extension are comparatively free.

Treatment.—Reduction is obtained by pressure upon the displaced bone with supination and manipulation. Support should be continued for three weeks or more.

Recurrent dislocation of the head of the ulna on pronation or supination may occur if the ligaments fail to unite.

Dislocation of the head of the os capitatum (*os magnum*) from the os navicular and os lunatum follows extreme palmar flexion of the hand. The flexed displaced head forms a prominence on the dorsum of the wrist, opposite the base of the third metacarpal, which temporarily disappears when the hand is dorsiflexed. There is an increase in the anteroposterior diameter of the wrist, flexion and extension of the wrist are limited, and there may be evidence of pressure upon the median nerve.

Treatment.—Reduction is obtained by pressure, flexion, and manipulation; and *retention* by dorsiflexion, which should be continued for one or two weeks.

Dislocation of the greater multangular bone (*trapezium*) follows forced flexion of the metacarpotrapezoid joint. There is a prominence at the base of the first metacarpal which moves as the thumb is flexed and extended.

Reduction is obtained by pressure. A molded splint to immobilize the joint should be worn for two or three weeks.

Dislocations of other individual carpal bones are rare.

For old or irreducible dislocation of the carpal bones open reduction or excision may be required.

Dislocations of the Metacarpal Bones.—Dislocations at the carpo-metacarpal joint are infrequent. Any or all of the metacarpal bones may be

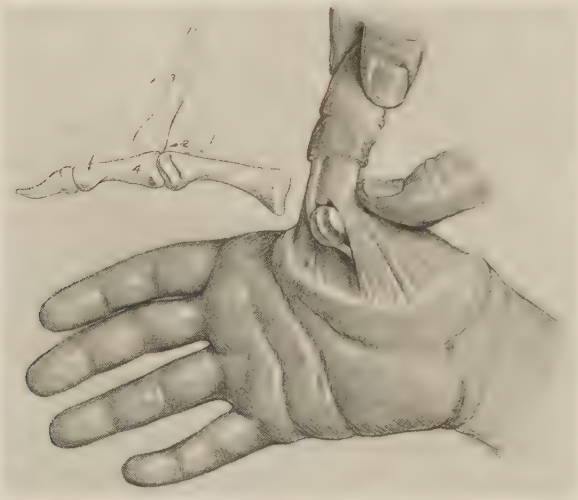


Fig. 212.—Complete dislocation of the thumb illustrating proper method of reduction. The thumb is hyperextended and the base pushed well beyond the head of the metacarpal bone (1, 2, 3) before flexion (4) is attempted.

separated from the carpus by forced flexion or extension. The metacarpal bone of the thumb is most frequently displaced, the base of the metacarpal forming a posterior prominence, easily reduced, but hard to retain. Pads should

Fig. 213.—Posterior dislocation of the thumb showing how flexion and traction convert the complete into the complex form.

be strapped over the projecting bone, and the thumb fixed in abduction on a palmar splint for two or three weeks.

Dislocation of the metacarpophalangeal joint is typified in *backward dislocation of the thumb*, and is divided into three forms:

1. The *Incomplete Form*, which some persons are able to produce at will by muscular contraction, the thumb forming an obtuse or right angle with the metacarpal bone.

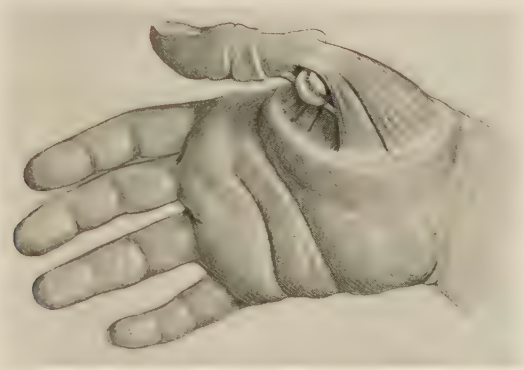


Fig. 214.—Complex posterior dislocation of the thumb. The thumb lies parallel but posterior to the axis of the metacarpal bone.

2. The *Complete Form:* From forced extension the first phalanx projects backward at a right angle, the terminal phalanx is flexed, and the head of the metacarpal bone forms a prominence anteriorly. The volar ligament is lac-

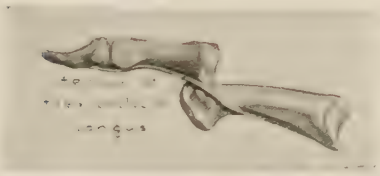


Fig. 215.—Backward dislocation of the thumb, complex form, showing the interposed long flexor tendon.

Fig. 216.—Complex dislocation of the thumb showing interposed sesamoid bone.

erated and, with the sesamoid bone, is pulled to the dorsal surface of the head of the metacarpal bone, the long flexor tendon slipping to the inner or the outer side.

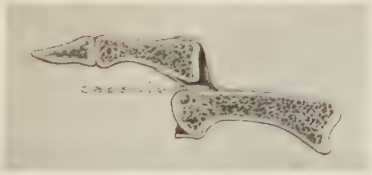


Fig. 217.—Complex posterior dislocation of the thumb showing how the ruptured volar (glenoid) ligament may be interposed between the bones and interfere with reduction.

3. The *Complex Form:* The thumb lies parallel with but posterior to the metacarpal bone. This is caused by flexion of the thumb in an attempt to reduce the complete form. The head of the metacarpal may be caught by the tendon of the long flexor, the volar ligament, capsule of the joint, or the tendon

of the flexor pollicis brevis containing a sesamoid bone. In reducing the complete form *extension should be increased*, with strong traction, while the base of the thumb is pushed down onto the head of the metacarpal bone before the thumb is finally flexed. If manipulation fails, the joint should be opened posteriorly, and the volar ligament and its attachments at the base of the phalanx sufficiently divided for reduction; or a palmar incision may be made over the head of the metacarpal bone, and the ligament incised between the sesamoid bones.

A splint should be worn for three weeks, gentle massage and manipulation being used after the first week.

Dislocation of the phalanges may be backward, forward, or lateral. The forward occurs by direct violence, the backward by hyperextension, the lateral by forcible abduction or adduction. The deformity and diagnosis are evident, and reduction usually easy. Traction and pressure or the Levis apparatus (two tapes to hold the finger passed through holes in a narrow board) may be used for reduction. A splint should be worn for one week.

Fig. 218.—Dislocations of terminal phalanx: *a*, Posterior; *b*, anterior.

Flexion of the terminal phalanx from rupture of the extensor tendon results chiefly from blows on the tip of the finger in playing ball. The injury occurs from the last phalanx being hyperflexed while the other joints are extended. Inability to actively extend the terminal phalanx follows. A hyperextension splint should be worn for four weeks or, rarely, an incision made and the tendon or avulsed scale of bone fastened to the phalanx.

Dislocation of the Hip.—Owing to the depth of the acetabular cavity and the great strength of the joint, this dislocation comprises only 3 per cent. of dislocations. It is produced by indirect violence, applied or transmitted from the feet, knees, or back with the hips flexed. The primary displacement is downward and mediad, as the thigh is thrust backward while adducted and rotated inward. Secondary displacements are backward or forward. It usually occurs in young, robust male adults, and is rare in children. After the age of fifty dislocation of the hip is unusual, fracture becoming progressively more common.

Varieties are: A. *Backward*—

1. *Dorsal*—on the dorsum ilii.
2. *Ischiatic*—on the sciatic notch.

B. *Forward*—

1. *Obturator*—on the obturator foramen.
2. *Pubic*—on the pubis.
3. *Perineal*—in the perineum.
4. *Central*—through the acetabulum.

The capsule is torn posteriorly or below at its weakest point, the strongest part of the capsule (the iliofemoral or Y-ligament) usually is unruptured. If ruptured, the dislocation may be of irregular type. The ligamentum teres and glenoidal labrum (cotyloid ligament) are torn. The untorn tendon of the

obturator internus, running over the neck of the femur behind, prevents the femoral head from riding up on the dorsum ilii. If the upper posterior portions of the acetabular rim are fractured, retention after reduction may be difficult.

Dorsal Dislocation.—The femur lies on the dorsum ilii, and can be felt in the buttock.

Atypical dorsal dislocations, due to the rupture of the Y-ligament, include the *supracotyloid*, the *intracotyloid*, and the *iliopectineal*. The term "*central dislocation*" has been applied to the driving of the head of the bone through the floor of the acetabulum.

Complications include lacerations of adjacent muscles, blood-vessels, or nerves, or the fracture of adjacent bones.

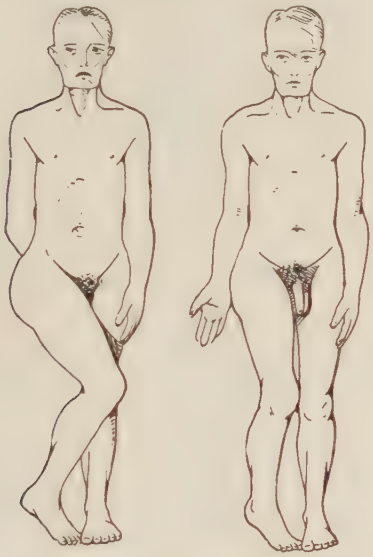


Fig. 219.—Dislocation of the hip with adduction: (1) Dorsal dislocation or above the tendon. (2) Ischiatic, sciatic dislocation, or dislocation below the tendon of the obturator internus.

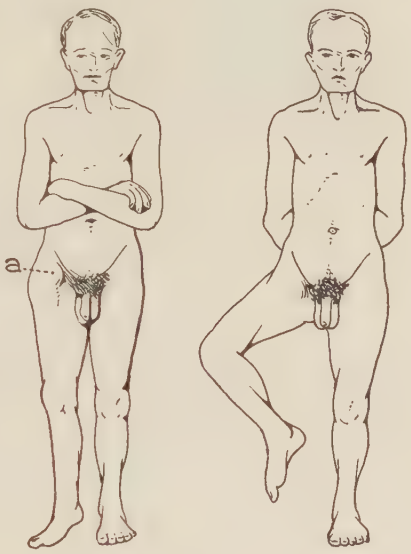


Fig. 220.—Dislocation with abduction: (1) Pubic dislocation; *a*, prominence from displaced head of femur under the inguinal ligament. (2) Obturator dislocation.

Etiology.—Dislocations on the dorsum ilii usually result from a fall, the patient alighting upon the feet; or from strong pressure upon the back, as from a heavy weight or blow, while the thigh is flexed, slightly adducted and rotated medially. In this position the femoral shaft forms the long arm of the lever, the Y-ligament the fulcrum, and the neck as the short arm of the lever forces the head against the lower and the back part of the capsule, causing it to give way. The head passes upward and backward on the dorsum ilii, above and anterior to the tendon of the obturator internus, which is often ruptured. The short rotator muscles are usually also lacerated, the trochanter is above Nélaton's line, and approximates the anterior superior iliac spine.

Position.—The leg is flexed, adducted, and inverted, the femur crossing the lower third of the opposite thigh, the toe being against the opposite instep.

The leg is shortened 5 to 8 cm., and there is a hollow in the femoral trigone and relaxation of the iliotibial band. The articular surface is directed backward, the trochanter forward. The patient cannot bear weight upon the limb or move it, and passive movements are painful. There is a characteristic elastic resistance on attempts at abduction and external lateral rotation. The head of the bone may be felt through the fibers of the glutæus maximus, and the gluteal fold is raised. Lordosis may partially compensate for the flexion of the thigh. If the lateral section of the Y-ligament is ruptured, dorsal dislocation with eversion may occur.

Fig. 221.—Iliac dislocation of the hip. The femoral head lies on the dorsum ilii above and anterior to the tendon of the obturator internus.

Fig. 222.—Sciatic or ischiatic dislocation of the hip. The femoral head passes beneath the tendon of the obturator internus into or adjacent to the sciatic notch. The Y-ligament is shown.

Sciatic Dislocation.—Dislocation below the tendon, or dislocation in the vicinity of the great sciatic notch, is less common, but occurs with the same mechanism. The head of the femur passes beneath the tendon of the obturator internus which, if not torn, lies over the neck of the femur and holds it down in the sciatic notch. The axis of the femur crosses the opposite knee, and the great toe rests on the dorsum of the opposite great toe. Shortening amounts to 2.5 cm. or less.

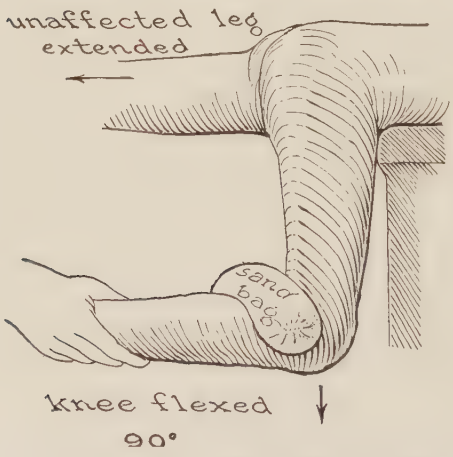


Fig. 223.—Stimson's postural method of reducing a posterior dislocation of the hip.

Diagnosis of backward dislocation of the hip is rarely difficult. Sciatic dislocation with but slight deformity may, in an obese person, be mistaken for an impacted extracapsular fracture. The type of injury, the absence of broadening of the trochanter, and the adduction and inversion of the limb are characteristic of the dislocation.

Treatment of Backward Dislocation.—1. *Gravity or Postural Method of*

Stimson: No anesthetic is required. The patient is placed on his face on a firm table, the thighs at right angles hanging over the edge of the table, the foot of the affected leg is supported, while a 7- to 10-kilo sand-bag is placed upon the flexed calf just below the knee. This position is maintained up to half an hour, or until the muscles relax under the additional weight and the bone is felt to slip back into place.

2. *Circumduction or Manipulation Method of Bigelow:* Under complete anesthesia with relaxation, "*lift up* (flex), *bend down* (abduct), *roll out* (rotate laterally)." The patient being supine on the padded floor, the knee and thigh are flexed in the position of slight adduction, relaxing the Y-ligament. The thigh is then slowly abducted and rotated outward by bringing the foot over the sound leg. This causes the head of the bone to retrace its path to the rent in the capsule, the external rotation relaxing the rotator muscles. These movements also tend to open the rent in the capsule. The leg is now quickly extended to the side of the opposite leg, to lever the head into the socket. Usually the thigh should be flexed to a right angle to the body, or slightly

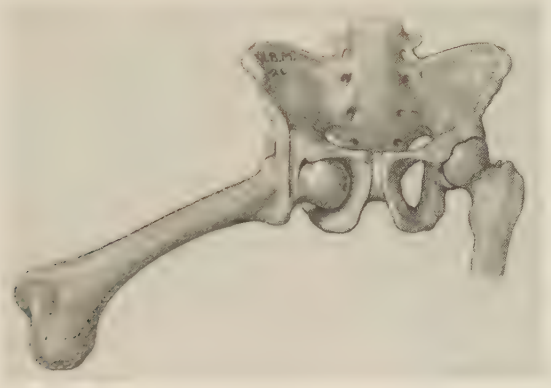


Fig. 224.—Obturator dislocation of the hip.

beyond the right angle. If overflexed, the head of the bone passes beneath the acetabulum, and the dislocation is converted into an anterior dislocation. Traction to lift the pelvis from the floor during abduction and eversion is often of value. If the posterior dislocation is converted into an anterior one, the appropriate manipulation should at once be adopted.

3. *Albee's Method:* (a) Flex, with downward and forward traction; (b) lift, rotating if necessary inward or outward or away from resistance; lift again, and (c) extend without force.

4. *Traction* with the thigh flexed at right angles to the body.

Obturator Dislocation.—The head of the femur lies at the obturator foramen on the obturator externus muscle.

Etiology.—It is due to great force applied through the back while the femur is flexed and abducted, as from a weight falling upon a man's back while he is stooping forward with the legs far apart. It also may be produced by wide, forcible abduction of the thighs. The capsule is torn in its lower part.

Symptoms.—The adductor muscles are lacerated, the trochanter is ob-

secured, the iliotibial band tense, the leg lengthened, the thigh slightly flexed and abducted, with the foot pointing directly forward or a little outward; the body is bent forward to relax the iliacus, psoas muscles, and the Y-ligament, the foot is advanced and drawn up. The patient may be able to walk, but is unable to abduct and extend the limb. There is apparent lengthening from tilting of the pelvis downward on the affected side. Flexion, abduction, and external rotation are well marked. At times the head of the femur can be felt in the perineum, and pain is referred to the distribution of the obturator nerve.

Dislocation on the pubis or pubic dislocation is a further degree of the obturator form, and is usually produced by forcible hyperextension and lateral rotation of the hip, as occurs when the body is bent back while the thigh is fixed, the capsule being torn farther forward than in the other varieties. The head rests on the superior ramus of the pubis against the iliopectineal eminence.

Symptoms.—The femoral head may be felt below Poupart's ligament, the leg is shortened about 2 cm., abduction and eversion are more marked than in the obturator dislocation, and the toes point outward.

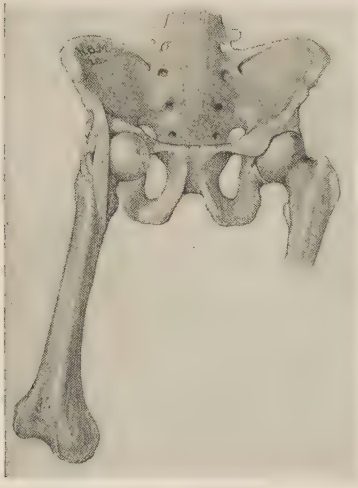


Fig. 225.—Pubic dislocation of the hip.

Treatment for Anterior Dislocation.—In the words of Bigelow: "*Lift up* (flex), *bend in* (adduct), *roll in* (rotate medially)." The thigh is flexed in the position of abduction, then adducted and inverted, and finally brought down straight with the opposite limb. Traction during the adduction and inversion is often of value.

In all dislocations of the hip traction with the thigh extended is to be avoided, as it prevents the essential relaxation of the Y-ligament.

After-treatment.—The patient is kept in bed with the thigh supported by sand-bags for two weeks, massage being used from the first, and cautious passive movements after the first week. After the second week the patient is permitted to go about with great care. In the old and rheumatic, secondary chronic arthritis with persistent pain and permanent disability may follow the injury, while atrophy and paralysis of muscles occur from the pressure upon or injury to adjacent nerves. If the rim of the acetabulum has been fractured, the patient should remain in bed for six to eight weeks with fixation in extension or abduction to prevent redislocation.

Chronic Dislocation.—Reduction by manipulation is difficult after the bone has been dislocated two or three weeks, and is rarely possible after eleven weeks have elapsed. Serious laceration of soft tissues and fracture of the femur have repeatedly followed forcible manipulations. Repeated attempts at reduction at intervals of three to five days, with continued traction in the interim, may be tried. If all these measures fail, open reduction may be attempted, using the skid of Kocher or Murphy. If the head of the bone cannot be replaced, it may

be excised. In chronic dislocations, where a new socket has formed with a fair degree of function, it may be wise not to interfere.

Reconstructive operations on the hip are required for: (1) Congenital dislocation of the hip, irreducible or not retained; (2) paralytic dislocation from poliomyelitis. (3) Ununited fracture of the neck of the femur.

Indications.—(1) Children, where reduction or retention is not possible. (2) Adults, with pain or instability. With paralytic dislocations reduction is easy, but retention difficult.

Operations.—(1) *Reduction into the true acetabulum with deepening of upper rim* by bone chips from lateral surface of ilium, through the incision of Sprengel or Smith-Peterson (Fig. 226). The leg is treated in abduction of 30 degrees. (2) *Formation of new acetabulum*—where the head cannot be reduced—as far forward as the old socket, without too great tension. The new acetabulum should

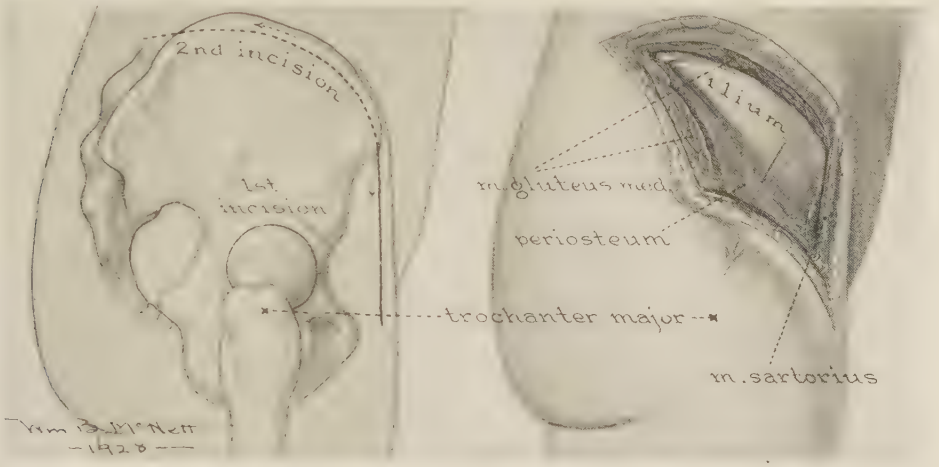


Fig 226.—Smith-Peterson incision. An approach to the hip-joint beneath the gluteal muscles.

not be too deep, and a bony ledge should be formed above the new socket. The cavity should be about 2 cm. deep, and no lining is required. The postoperative treatment is fixation in abduction of 30 degrees. (3) *Formation of supporting shelf* of bone on lateral surface of ilium, without the formation of a new acetabulum.

Campbell's Operation: (1) Exposure by Smith-Peterson incision. (2) A chisel is driven into the ilium 1 cm. above acetabulum, and the entire upper portion of socket with the cartilage displaced outward for 2 or 3 cm. over the head of the femur. (3) Fixation in abduction. (4) Weight bearing may be started in two months if the union is satisfactory.

Sprain of the hip is relatively rare, resulting from milder forms of the same forces that produce dislocation. A stretching or partial tearing of the ligaments, effusion into the joint with local tenderness and pain on movement are present. From the distention of the joint there is slight flexion, abduction, and external rotation of the thigh.

The *treatment* is by rest, massage, fomentations, baking. Secondary adhesions, arthritis, chronic pain, or tenderness may follow.

Contusions of the hip may simulate a fracture. The limb is usually in a position of slight flexion, with, at times, marked swelling, local tenderness, and disability. The bony points retain their normal relationship, the measurements are not altered, and the roentgenogram is negative. *Secondary arthritis, arthritis*

deformans, and even absorption of the neck of the femur occur, especially in the middle aged, elderly, or rheumatic.

The *treatment* is by removal of foci of infection, massage, fomentations, diathermy, vaccines, and the like.

Congenital dislocation of the hip forms 90 per cent. of congenital dislocations, and is three times as common in girls as in boys. One-fourth of the cases are bilateral.

Pathology.—The acetabulum is too small for the head of the femur, is flat, shallow, imperfectly developed, and partially filled by fibrofatty tissue from the synovial membrane. The glenoidal labrum being broader and thicker than usual, the bony socket appears deeper than it really is, although the cartilaginous rim of the acetabulum is absent. The affected half of the pelvis is undeveloped, the femoral head is small, flattened, and occasionally conical. The angle of the neck is altered, being diminished or increased. A torsion of the neck may render it difficult to retain the head in the socket. The capsule is stretched and relaxed, the ligamentum teres elongated, especially in bilateral cases. From walking the capsule becomes lengthened, with an hour-glass constriction, preventing the head of the bone from pushing through it into the socket. After the age of five or six years one or more sockets may have formed on the ilium from pressure, differing from traumatic cases in that the thickened capsule prevents the formation of a deep and adequate new socket. Usually there is dorsal luxation, the pelvis tilting forward with a marked lordosis of the lumbar spine. The gemelli, obturators, and piriformis are lengthened; the adductors, hamstrings, iliacus, and psoas muscles are shortened, while the glutei and quadriceps are little altered. Rarely the head is displaced upward, lying immediately above the acetabulum.

Symptoms.—The child begins to walk late, the condition often being first noted at this time. The gait is waddling and rolling from side to side, with a lump in the buttock, flattening about the hip, or peculiar position of the thighs. The limb is shortened, the shortening increasing with use (up to 10 cm.). The gluteal fold is shorter, deeper, and higher than on the well side, and there is a lateral curve of the lumbar spine with its concavity toward the affected hip. All movements are free except abduction; the buttocks are very prominent behind, the hips are broad laterally, the abdomen protuberant, and lordosis is always present, with a scoliosis in unilateral cases. The heel is not brought to the ground on the affected side, and shortening is compensated by flexing the well knee. There is an increased gap at the perineum between the thighs. In unilateral cases the lameness is less marked, but there is a difference of from 3 to 10 cm. in the length of the legs. Roentgenograms usually show the trochanter on a level with the anterior superior spine, the head of the femur absent or malformed, the acetabulum deficient in its iliac segment, and the angle between the neck and the shaft more obtuse than normal (*coxa valga*).

Diagnosis.—In a congenital traumatic dislocation there is a history of dystocia, the limb cannot be pulled down, and the roentgenogram shows a normal acetabulum and head of the femur.

Tuberculosis of the hip develops after birth. Pain, spasm, and rigidity are present, and the femur cannot be pulled down.

Coxa vara develops in childhood or puberty, after the child has walked well, and often after a fall. There is eversion, abduction is restricted, and the leg cannot be pulled down. *Trendelenburg's test* depends upon the relative level of the buttocks when the patient stands on the affected leg and flexes the opposite thigh. Normally the buttocks remain on the same level when the patient stands on one leg. In congenital dislocation the buttock of the raised limb is lower, in coxa vara it is higher than that of the abnormal side.

Treatment.—A. *Bloodless Reduction of Lorenz:* Under anesthesia the child is placed on its back with the legs over the end of the table, an assistant steadying the pelvis. Manipulations consist of:

1. *Traction* until the trochanter is brought down to Nélaton's line.

2. *Forced rotation* outward and inward, and forcible abduction to a right angle, with kneading of the adductors until they are thoroughly stretched or torn.

3. *Stretching the hamstrings*, by bringing the anterior thigh in contact with the abdomen and the toes to the face.

4. *Stretching the anterior muscles*, the patient being turned on the side or face, and the hip hyperextended both directly posteriorly and in abduction.

5. *Reduction.*—With the child on its back, the knee is grasped with the thigh flexed to a right angle, and rotated laterally while the thumb (pushing from behind on the trochanter) guides and lifts the head of the bone over the rim of the acetabulum, as the hip is over-adducted. The procedure may be facilitated by a padded wedge of wood about 3 inches high. Reduction may occur with a distinct snap.

6. *Retention.*—After applying stockinette drawers and carefully padding all bony prominences, the lower trunk (including the costal margins) and both thighs to the knee are encased in plaster, the limb being maintained in a position of right-angled abduction and external rotation of 90 degrees. The child is permitted to be out of bed and to walk with a high sole on the affected side, but without crutches, after the first two weeks. The abduction is gradually reduced, and the plaster is discarded after six months, when massage and exercise are adopted. If the first attempt at reduction fails, plaster retention in abduction should be used for ten days to two weeks, and then another attempt may be made. Reduction has been accomplished up to the age of seven. Where reduction fails, the *Lorenz anterior transposition* of the head of the femur, the head being wedged under the long head of the rectus muscle; or, if this fails, transposition below the anterior iliac spine under the sartorius and tensor fasciæ femoris may be used.

B. In older patients, or where the manipulation fails, *open reduction* is used with separation of the tissues from the outer surface of the ilium and the acetabulum. The capsule is opened, the hour-glass constriction divided, the acetabulum reamed out, the head of bone contoured and reduced, with closure of the soft tissues. Fixation by a plaster case, in abduction with use of the leg for walking, is continued for four to six months.

C. *Subtrochanteric osteotomy* with fixation in full abduction is useful where arthroplasty is not feasible.

Congenital dislocation of the knee is rare and usually incomplete. The patella may be absent. Occasionally subluxation may be produced at will. An apparatus to prevent hyperextension or lateral motion may be required. The congenital absence of the patella is usually associated with other abnormalities of the knee-joint, the extensor tendon being unusually thick and tending to rise on the lateral condyle of the femur during contraction.

Congenital lateral dislocation of the patella may be persistent or intermittent. In the former, the patella rests on the trochlear surface of the lateral condyle and, when the knee is flexed, may pass farther laterad, becoming completely dislocated, lying against the lateral aspect of the condyle.

In the intermittent form, the patella is in normal place, but subject to lateral displacement when the knee is flexed, causing the patient to fall to the ground in intense pain. On extending the joint the knee-cap is readily replaced. The condition may cause sprain and effusion in the knee-joint, with temporary disability. It occurs chiefly in girls. It is differentiated from tuberculosis by the undue mobility of the patella.

Treatment.—(1) A strong supporting knee-cap. (2) Open operation with retrenchment, or folding and suture of the redundant capsule at the medial side of the patella. (3) Medial displacement of the tuberosity of tibia with attached ligamentum patellæ. The tuberosity is fastened by bone pegs or sutures in its new position.

Dislocation of the Patella.—Varieties: (1) *Lateral;* (2) *medial;* (3) *vertical* with rotation.

Etiology.—The dislocation may result from muscular action or direct violence, the predisposing causes being hydrarthrosis, or genu valgum or varum. Dislocation upward or downward is due to rupture of the patellar tendon, the patellar ligament, or the quadriceps tendon, and should be treated by suture of the divided structures.

1. **Lateral dislocation** is the most frequent, being (a) *complete* when the patella lies upon the lateral surface of the lateral condyle, with the medial border forward; or (b) *incomplete* when the patella rides upon the lateral condyle, the lateral edge forming a projection. The knee is broadened, the leg extended, and the depression of the intercondyloid notch very perceptible. *Reduction* is accomplished by flexing the thigh on the abdomen and extending the knee to relax the quadriceps, while appropriate pressure is made on the lateral border of the patella. To prevent recurrence the knee should be fixed by splint, case, or strapping for two or three weeks, and a knee-cap or knee-truss worn for three or four months. Occasionally operative treatment may be required to accomplish reduction or to prevent recurrence, as in congenital dislocation of the patella.

2. **Medial dislocation of the patella** is rare, its *incomplete* and *complete* forms corresponding to those of the outward dislocation.

3. **Rotation in the Vertical Axis (Vertical or Edgewise Dislocation).**—The medial or, more rarely, the lateral border of the patella lies between the condyles, the opposite border projecting forward. Rarely the bone is completely turned over so that the articular surface is forward.

Reduction is attempted by flexing the thigh on the abdomen, extending the

knee with local pressure and manipulation. An open operation may be necessary for satisfactory reduction.

Rotation on the horizontal axis is very rare, the quadriceps tendon usually being torn, and the upper border of the patella being wedged between the femur and the tibia. More rarely the lower edge of the patella is in the joint, the articulating surface looking upward.

Treatment.—Operation is usually desirable to free the bone and to sew the torn tendon.

Dislocation of the medial meniscus of the knee (*subluxation of internal semilunar cartilage, internal derangement of the knee*) usually follows a twist of the partially flexed knee, and may occur from: (1) Violent rotation of the body as the person stands on one leg; (2) a missed kick, or any very sudden twist. The condition usually involves the left knee of young adult males. The patient often falls to the ground in extreme pain, with the knee locked and a sense that something has given way in the knee. The knee is slightly flexed, extension is very painful and resisted; there is tenderness between the tibia and femur on the medial side, and a secondary synovial effusion usually rapidly follows.

Diagnosis.—In a sprain, the maximum tenderness is over the tendinous attachment to the bone (as the tuberosity of the tibia); in the medial derangement, the maximum tenderness is between the bones. The medial meniscus is affected in 95 per cent. of the cases, because it is more fixed and is subject to the greater movement of the overlying medial condyle. It may be detached at (a) one or (b) both extremities from the tibia; (c) along its edge from the capsule and tibial collateral (internal lateral) ligament; or (d) internally from the coronary ligament. It may be (e) divided into two or more pieces, and become displaced into the joint, forming a loose body which may become located between the joint surfaces or in the intercondyloid notch.

Repeated attacks create a chronic synovitis, relaxed and weakened ligaments, and thickened synovial membranes, with free edges converted into fibrous fringes. Occasionally the displaced and movable cartilage may be felt.

Treatment. For reduction the knee is fully flexed, then rotated laterally with abduction, followed by sudden extension; or alternate flexion and extension combined with rotatory movement may be tried. The patient is then treated as for an acute synovitis. After the immediate synovitis has subsided, the patient may be permitted to go about with a posterior splint or plaster case for six weeks, followed by the use of a firm bandage or knee-cap for three months longer. If recurrence takes place, the cartilage should be removed.

Operation (Jones).—With the knee flexed to a right angle, an oblique incision about $2\frac{1}{2}$ cm. long is made over the edge of the affected cartilage. The joint is opened, the cartilage removed by a hook, knife, and scissors; hypertrophic tabs of synovial membrane are resected, and the wound closed without drainage. Excision is preferred, as suture of the cartilage frequently fails to hold. If operation is refused a retentive appliance that permits flexion and extension but not rotation, such as a knee-truss or knee-cap, should be worn constantly while the patient is about. Functional ability to do heavy work is retained after removal of the medial meniscus.

Rupture of cruciate ligaments usually follows great violence and partial

dislocation. The anterior ligament is attached to the lateral condyle of the femur and to the front of the intercondyloid eminence of the tibia, and is tense during extension of the knee. When ruptured, there is abnormal mobility in extension, and the tibia tends to slip forward on the femur. The posterior ligament is attached to the medial condyle of the femur and to the posterior intercondyloid fossa of the tibia, and is tense during flexion of the knee. When ruptured, there is abnormal mobility in flexion, with a tendency to backward displacement of the tibia on the femur.

Treatment.—A case or splint is applied, with the knee in the position to give the greatest relaxation of the torn ligament. After four weeks a hinged brace or splint, which will prevent the tibia from slipping forward or backward, is applied and worn for three months. If the disability persists, the constant wearing of a brace or the introduction of new ligaments of tendon or silk is indicated.

Operation.—The lateral condyle and the head of the tibia are drilled, and a strong strip of the fascia lata drawn through to replace the anterior liga-

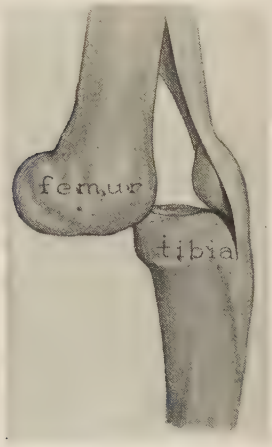


Fig. 227.—Forward dislocation of the knee.

Fig. 228.—Backward dislocation of the knee.

ment; while for the posterior ligament the medial condyle and head of the tibia are drilled, and the semitendinous and gracilis tendons threaded through.

Dislocations of the Knee-joint.—The knee (tibia) may be dislocated (1) forward, (2) backward, (3) mediad, or (4) laterad. The condition is rare, usually incomplete, and associated with extensive lacerations of the tendinous structures about the joint. As a rule it is due to extreme violence with wrenching or twisting. *Gangrene* may occur from rupture or pressure upon the popliteal vessels; or *paralysis* from pressure upon the tibial or common peroneal nerve. The dislocation may be compound and followed by dangerous septic processes.

Dislocation forward is the most common. It is caused by sudden hyperextension of the knee, with rupture of the collateral and crucial ligaments.

Symptoms.—The leg is extended, on a plane anterior to that of the thigh, the condyles of the femur project posteriorly, the patella is carried forward,

and the quadriceps tendon and the overlying skin are relaxed. There may be 5 or 8 cm. of shortening.

Dislocation backward usually results from direct force driving the tibia backward or the upper end of the femur forward, the leg being hyperextended with the head of the tibia in the popliteal space, while the condyles project forward with the patella either in front or to one side.

Medial and lateral dislocations usually are incomplete, and may be mistaken for separation of the lower epiphysis of the femur. In the medial dislocation, the lateral condyle of the femur projects laterally with a depression below it. The head of the tibia projects medially, with a depression over the medial condyle. In lateral dislocation, the relative positions of the prominences and depressions are reversed.

Dislocations of the upper end of the fibula usually follow indirect violence, with twisting applied to the foot or leg, or muscular contraction of the biceps. The varieties are *anterior* and *posterior*. There is no interference with the movements of the knee-joint, but the pain prevents walking. It is frequently associated with severe or compound fracture of the bones of the leg.

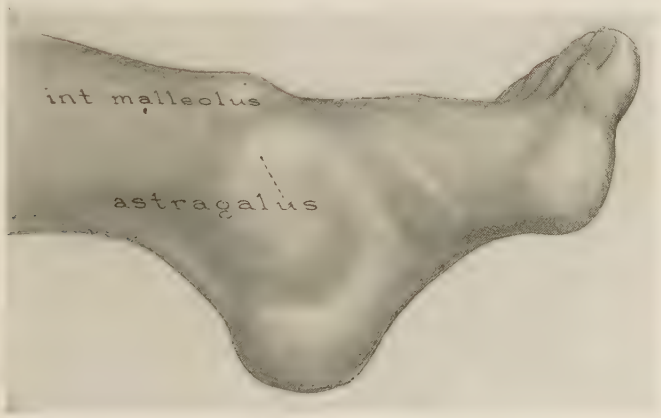


Fig. 229.—Medial and posterior dislocation of the foot.

Reduction is readily accomplished by direct pressure with the knee flexed, and retention should be continued for four or five weeks by adhesive strapping, bandaging, or the use of a light splint.

Total Dislocation of the Fibula.—Very rarely the entire fibula is separated from the tibia and displaced upward. A congenital malformation, in which the upper end of the fibula does not reach the facet of the tibia, is described by Bennett, of Dublin. This condition may be mistaken for a dislocation of the upper end of the fibula.

Dislocations of the Ankle-joint.—1. **Dislocations of the foot** (between the talus and the tibia and fibula) are described, according to the direction in which the foot passes, as (a) *backward*, (b) *forward*, (c) *medial*, (d) *lateral*, or (e) *upward*. Usually they are associated with fracture, frequently they are compound. Dislocations medial or lateral occur in association with Pott's fracture or a fracture of one or both malleoli, from a turning or twisting of the

foot. The ankle is broadened, the malleoli unduly prominent. *Dupuytren's fracture* with outward dislocation is the most common of these dislocations. Backward dislocation is the most common unassociated with fracture, and often is associated with Pott's fracture. Backward dislocation results from extreme plantar flexion of the foot, the ligaments are torn, one or both malleoli

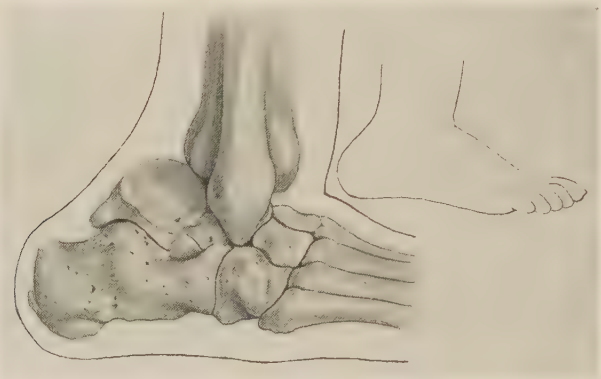


Fig. 230.—Backward dislocation of the foot showing lengthening of the heel and shortening of the anterior part of the foot.

may be broken, and the posterior articular edge of the tibia fractured. The foot appears shortened and the heel unduly prominent, while the malleoli project anteriorly; the distance from the malleoli to the heel is increased, the distance from the malleoli to the toe diminished. The deltoid and lateral ligaments are ruptured or the malleoli fractured.

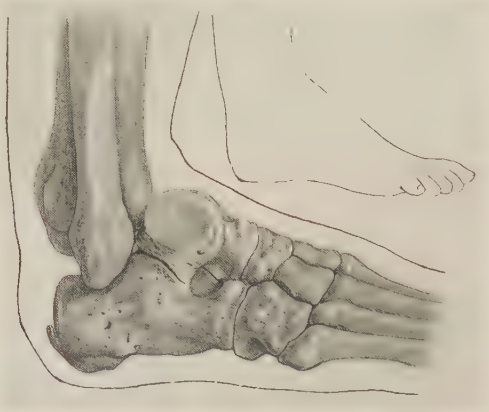


Fig. 231.—Anterior or forward dislocation of the foot showing shortening of the heel and lengthening of the anterior part of the foot.

In *forward dislocation*, the ligaments or malleoli are divided, the heel is shortened, the distance from malleoli to the heel is diminished, while that from the malleoli to the toes is increased. This condition results from extreme dorsal flexion of the ankle-joint. The foot appears lengthened, the hollows at the side of the tendo calcaneus (achillis) are obliterated, and the talus is felt in

front of the tibia. The malleoli appear to be displaced backward and to lie nearer the sole.

Upward dislocation occurs in severe types of Dupuytren's fracture, the talus being driven upward between the tibia and fibula. The interosseous ligament is ruptured, with great broadening of the ankle; the malleoli being unduly prominent and nearer the sole, while the movements of the ankle-joint are lost. The deltoid and talofibular and calcaneofibular ligaments are torn, and there is shortening of the leg.

Reduction of these dislocations is usually readily accomplished under an anesthetic. The knee is bent to relax the tendo calcaneus, and traction, rotation, flexion, or extension and direct pressure used. In forward dislocation it may be necessary to divide the tendo calcaneus. In upward dislocation an open operation may be required to obtain satisfactory reduction.

Treatment after reduction is as for Pott's fracture. In compound dislocations amputation may be necessary, especially in the aged and enfeebled.

2. **Dislocation of the talus** (*astragalus*) is not uncommon and may be complete or incomplete. Complete dislocation, so that the talus loses its relation to the bones of the leg as well as to the other bones of the tarsus, is rare. The varieties are: (a) forward, (b) backward, and (c) rotatory. The forward dislocation usually occurs when the foot is plantar-flexed at the time of injury, the displacement being usually forward and laterad, occasionally forward and mesiad. The foot is abducted, inverted, and displaced medially, while the talus rests on the third cuneiform and cuboid bones. Frequently the injury is compound. Backward dislocation occurs when the foot is dorsiflexed at the time of injury, but this is rare. Median or lateral dislocation is very rare. Rotation on the sagittal axis, the talus being rotated in its socket, is rare and usually is combined with plantar or dorsal displacement. *Reduction* is attempted under anesthesia with the hip and knee flexed, using traction, manipulation, and direct pressure upon the displaced bone. In incomplete dislocations this usually succeeds; in complete dislocations an open operation, with division of the lateral malleolus or the excision of the talus, is usually necessary. In compound dislocations talosectomy (*astragalectomy*) often is indicated.

3. **Subtalar** (*subastragaloid*) **dislocations** occur between the talus, calcaneus, and navicular, the talus retaining its normal relationship with the malleoli (*talocrural articulation*). The displacement is usually backward or, very rarely, forward. *Backward dislocation* may also be medial, the head of the talus resting on the cuboid and projecting on the lateral part of the dorsum of the foot. The heel is lengthened, the dorsum of the foot shortened, the toes adducted, and the medial part of the foot raised. The lateral malleolus is unduly prominent and reaches nearly to the sole. The distance from malleoli to heel is increased, the distance from malleoli to toes decreased, the foot is plantar-flexed and inverted, as in equinovarus, or everted like an equinovalgus.

In backward and lateral dislocation the head of the talus projects toward the inner side of the foot, which is abducted and everted. In both forms the movements of the ankle-joint are maintained.

Treatment.—Reduction is to be carried out as for dislocation of the talus. While usually this is not difficult, an open operation for reduction or excision

of the talus occasionally is necessary. After reduction, a fracture-box should be used until the primary swelling and reaction have subsided, when a plaster case may be applied for four weeks, the foot being kept slightly abducted, and at right angles to the leg.

4. **Midtarsal or transverse tarsal dislocation,** occurring at the talocalcaneonavicular or calcaneocuboid articulation, is very rare. The distal part of the foot is usually displaced toward the sole, the foot shortened, the malleoli raised from the sole, and the arch of the foot is obliterated, while the first row of tarsal bones projects on the dorsum.

Reduction is accomplished by extension, manipulation, and direct pressure, followed by support in the corrected position for four weeks, with the associated use of graduated massage and passive movements.

5. **Tarsometatarsal dislocation** may involve one or more of the metatarsal bones. The displacement is usually toward the dorsum or laterally. Plantar displacement of the tarsals is rare. There is a forward, backward, or lateral displacement, with a corresponding shortening of one or more toes, or, if the entire row is displaced, there is shortening of the foot. The base of the second metatarsal or the first cuneiform may be fractured.

Reduction is accomplished by extension, pressure, and manipulation and usually is easy in dorsal dislocations, but may be so difficult in the lateral variety, due to intervening bone or soft parts, that an open reduction is necessary. In old-standing dislocations of this variety, without disability, operation is not required.

Dislocations of the toes are rare, the metatarsophalangeal joint of the great toe being most frequently affected, and the proximal phalanx passing toward the dorsum of the foot. Reduction is easy.

Interphalangeal dislocations are rare and are easily recognized and reduced.

CHAPTER XVIII

THE MUSCLES, TENDONS, AND BURSÆ

MUSCLES

Congenital anomalies, including absence or hypoplasia of particular muscles (especially the pectoralis major), or parts of a muscle, and accessory muscles, are rare.

Atrophy of muscles follows diminished use, as from fixation of adjacent joints, paralysis, or reduction in the blood-supply.

Contusion of a muscle from a blow may cause rupture of the sheath and muscle-fibers, effusion of blood and serum, with tenderness, swelling, and pain on contracting the muscle. Perfect restoration of function is usual, unless the nerve-supply has been severely damaged or secondary degeneration, calcification, or ossification occurs.

Hernia of Muscle.—Through a defect in the sheath the muscle protrudes, while relaxed, forming a soft rounded swelling which disappears when the muscle contracts. It most frequently involves the adductor longus. The muscular mass may be mistaken for a tumor, cyst, dilated blood-vessel, or an obturator hernia. If troublesome, the muscular sheath should be exposed and sutured, or covered by a fascial transplant.

Strain results from the overstretching of fibers of muscles or tendons. The strain may involve the long head of the biceps, *glass arm;* the pronator teres about the elbow, *lawn-tennis arm, sculler's sprain;* the extensors and supinators about the elbow, *angler's elbow;* the adductors of the thigh, *rider's leg;* the sacrospinalis and latissimus dorsi, *golfer's* or *laborer's back;* the flexors of the hip, *sprinter's strain;* the calf muscles, *jumper's* or *dancer's sprain.*

Symptoms are pain, tenderness, and loss of power, referred to the affected muscle.

Treatment.—Rest, relaxation, and hot fomentations; later massage and passive movements. The muscle should be relaxed, supported by strapping or bandage, and strain on the muscle in the line of production of the injury should be delayed until healing has occurred. The disability may later persist from adhesions, and be relieved instantly and dramatically by forcible full movements with or without anesthesia, as practised by "bone-setters" and practitioners of mechanotherapy.

Rupture of a muscle usually occurs at the junction of the muscular and tendinous portions. Muscles that have degenerated, as from typhoid, pneumonia, or other debilitating diseases, are prone to rupture. In such disease a local myositis with a tendency to abscess formation often occurs, especially in the rectus abdominis. Under violent strain (voluntary as in parturition, or involuntary as in tetanic convulsions) a normal muscle may give way. The rupture is often caused by a sudden semi-automatic movement, as in an effort to regain the balance of the body.

Symptoms are sharp stinging pain, loss of power, and a secondary hematoma as the gap left by the separated muscle-fibers fills with blood. With rupture of the long head of the biceps, the patient cannot fully adduct or elevate the arm and, on contraction, the muscle forms an abnormal distal and medial mass. Rupture of the adductor longus, which usually is near the pubic attachment, reduces the power of adducting the thigh; of the quadriceps femoris, reduces the extension of the leg; and of the plantaris, causes pain in the calf on raising upon the toes.

Treatment.—A ruptured muscle should be treated by rest and support in the position of relaxation. If the function of the muscle is important, operative exposure and suture of the muscle and its sheath are indicated.

Open wounds of muscles do not gape, if in the line of the fibers, and rarely cause disability. If across the fibers, the divided ends retract and an early suture is desirable. As it is difficult to suture the soft muscular substance, support for the sutures must be taken largely from the overlying sheath, and the muscle put at rest in a position of relaxation until healing has occurred.

Fig. 232.—Rupture of the right biceps muscle from muscular action.

Fibrositis (Gowers, 1907).—Muscular rheumatism is characterized chiefly by an inflammatory hyperplasia of the connective-tissue framework of muscles. The condition is usually a metastatic expression of a focal infection, cold or exposure, or strain. It chiefly affects the lumbar muscles (*lumbago, lumbosacral fibrositis*), the gluteal muscles (*gluteal fibrositis*), the neck (*acute stiff neck, rheumatic torticollis*), the intercostal muscles (*pleurodynia, intercostal fibrositis*), the shoulder (*brachial fibrositis*), and other parts.

Treatment.—(1) Removal of the focus of infection. (2) Elimination. (3) Locally: Massage, heat, cupping, injection of warm water or of 2 per cent. phenol into the affected muscle. (4) Treatment of the underlying constitutional condition by salicylates, iodids, quinin, or other drugs as may be required.

Myositis.—Inflammation of a muscle. Septic myositis may be metastatic, by contiguity, or a specific infection as from the gas bacillus. After pneumonia, typhoid, or other infection an abscess may form in a muscle (particularly in the rectus abdominis) which should be incised and drained. Gas-bacillus infection should be treated by excision, disinfection, perfringens antitoxin, and, if necessary, by amputation.

Myositis ossificans is the abnormal growth of bone in muscle and fascial planes. *Traumatic type* may follow: (1) The *stripping* or *elevation of periosteum* from the bone, with secondary ossification of the effused blood, or osseous metaplasia of adjacent soft tissue. This form is most frequent in the brachialis after posterior dislocation of the elbow, and in the quadriceps femoris after local injury of the muscle. A large swelling develops three or four weeks after the injury in front of the lower end of the humerus or in the anterior femoral muscles, and is followed by quiescence or growth; (2) *from muscular traumatism*, as with *rider's bone* (Billroth), an ossification of the adductor longus following bruising or partial rupture of the muscles, occurring especially in cavalry soldiers. In *drill bone* an area of ossification forms in the deltoid and pectoral muscles of soldiers, from bruising by the rifle in drill.

Diagnosis.—The mass is bony hard, rarely painful, does not tend to grow, and is apparent in the roentgenogram.

Treatment.—Excision if there is pain, deformity, or disfigurement.

Progressive ossifying myositis (*myositis ossificans progressiva*) is an irregular, generalized, progressive ossification in or adjacent to the voluntary muscles.

Etiology.—Ossifying myositis develops in infancy or before the age of ten, especially in boys, and is often associated with microdactylia or valgus deformity of the great toe and thumb, shortening of the metatarsal bones, and, occasionally, ankylosis of the phalanges. The cause of the disease is unknown.

Pathology.—There is an exudation of grayish plastic material, between or in the muscles, which becomes gritty from the impregnation of lime salts, and gradually calcifies and ossifies. The exudation may be associated with recurrent acute paroxysms of pain and swelling, and great coral-like bony masses are finally formed.

Symptoms.—Swelling and deformity, with moderate tenderness but without edema or redness of the skin, occur with a gradual tendency to deformity and fixation of the various muscles and joints, finally rendering the patient unable to move or even masticate. The disease involves chiefly the muscles of the trunk, upper extremities and neck, the trapezius, latissimus dorsi, sternocleidomastoideus and shoulder muscles, with local soreness, stiffness, doughiness, and cyanosis. Recurrent exacerbations occur with the deposit of new calcific masses.

Diagnosis is to be made from injury, rheumatism, congenital multiple exostosis.

Prognosis.—Death results in ten or twelve years from intercurrent disease, as bronchial pneumonia, or from involvement of the masseter muscles and starvation.

Treatment is unsatisfactory, but the deformity may be somewhat relieved by early incision and removal of the plastic calcifying material. Multiple and very extensive operations are, however, required.

Iodids, parathyroid and epinephrin feeding may be tried, with, unfortunately, little promise of benefit.

Muscular contractures occur from paralysis, and after rheumatic, gouty, or other infections, and may lead to false ankylosis of joints.

Contractures (including those from infantile palsy) are to be treated by extension, massage, passive movement, mobilization under anesthetic, myotomy, or tenotomy.

Paralysis of Trapezius Muscle.—Due to the insufficient power of the levator scapulæ, the scapula protrudes until the arm is raised, when it approximates the chest. In serratus paralysis the scapula leaves the chest wall when the arm is abducted (see Scapula alata).

Cysts of muscle are produced by parasites or degeneration. The *Cysticercus cellulosæ* (measle of the tapeworm of the hog, *Tænia solium*) and the *Trichina spiralis* form minute cysts, while the echinococcus produces large cysts in the rare instances in which it locates in muscles.

Tumors of muscle, excepting the congenital rhabdomyoma, usually grow from the intermuscular septa and connective-tissue framework rather than the muscular substance proper. The benign tumors are rare, and include fibroma, lipoma, angioma, chondroma, osteoma, and myoma. Primary malignant tumors are sarcomatous; most common is the *fibrosarcoma, recurrent fibroid of Paget*, or *desmoid tumor*—a firm, rounded, encapsulated tumor, under the microscope resembling a soft fibromyoma, usually slowly growing in the muscles of the abdominal wall of women. Carcinoma frequently invades the muscle secondarily. A tumor of a muscle becomes fixed by the contraction of the muscle, and in relaxation it is movable transversely to, but not in the line of the muscular fibers.

TENDONS

Tenosynovitis (*thecitis, inflammation of a tendon sheath*) may be acute or chronic.

Acute tenosynovitis chiefly involves the tendons of the thumb and wrist, and the peronæi tendons of the ankle after muscular strain or a contusion. *Achillodynia* follows strain or irritation of the tendo calcaneus. Focal infection, gout, and rheumatism are predisposing causes. There is pain and tenderness over the tendon, increased by movement, producing a fine palpable or even audible crepitus, *tendon crepitus*, like the creaking of new leather.

Treatment.—Relaxation and rest of the affected tendon, with evaporating lotions, embrocations, and treatment of any underlying constitutional condition. If suppuration occurs (*purulent tenosynovitis*) early incision and free drainage should be instituted.

Chronic tenosynovitis may be: (1) *Dry*, with roughness and crepitus; or (2) *exudative*, with mucilaginous, gelatinous, or puriform exudation into the sheath. Rounded bodies may form and be palpable (*riziform, rice-*, or *melon-seed bodies*). Irregular deposits of the chalky urate of soda (*tophi*) occur in gout. Arborescent lipoma or overgrowth of the fatty fringes of the synovial sheath occurs, especially in tuberculous thecitis. Tenosynovitis may be gouty, rheumatic, gonorrheal, tuberculous, or syphilitic. In tuberculosis there may be serous effusion (*hydrops*), or the formation of tubercles and caseation. Chronic thickening, hour-glass shaped or compound ganglia and sinuses also occur.

Treatment.—Rest, splinting, counterirritation, radiation, tuberculin, or excision or curetting of the effected part of the sheath without drainage. In syphilis, effusion and gummatous formations involve the tendon sheaths.

Ganglion is a localized effusion in a tendon-sheath, filled with whitish gelatinous fluid, usually forming a rounded elevation over the extensor tendons of the wrist. The localized swelling is usually painless, unless rapidly enlarging, and may be due to a localized thecitis or a herniation of the synovial lining, or a colloid or mucoid degeneration of the synovial fringe.

Fig. 233.—Compound ganglia of the back of the left hand.

Treatment.—(1) Rupture by striking the tense ganglion by the back of a book; (2) aspiration; (3) puncture and expression, followed by pressure of a pad and bandage; (4) the injection of tincture of iodin, or (5) excision.

Compound ganglion is one with loculi above and below the annular ligament. It is usually tuberculous.

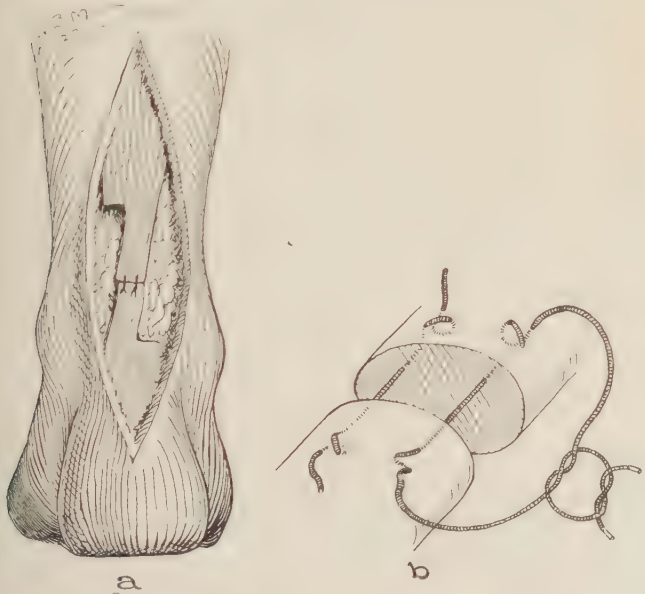


Fig. 234.—*a*, Anderson's or Z method of lengthening the tendo achillis. *b*, Tenorrhaphy, Wilms' method of suturing a divided tendon.

Fig. 235.—Stöffel's method of suturing a divided tendon. The ends of the tendon should be approximated before the suture is tied.

Tumors of tendon-sheaths are rare, and include lipoma, fibroma, myxoma, or the rather benign giant-cell tumor of the wrist, ankle, or fingers. The *treatment* is excision.

Sarcomata occasionally grow from tendon-sheaths, and are to be treated by early excision or radiation.

Dislocation of tendons is most common with the peronæi and long head of the biceps. The condition may be recurrent, and be accompanied by an audible painful snap and functional derangement.

Treatment is *reduction* by manipulation, and *retention* by strapping and a bandage. If recurrent, the tendon should be exposed, and the sheath or fascia so sutured as to prevent further displacement.

Operations Upon Tendons. -The nutrition of tendons is largely through the blood-vessels of the peritenon which, in operations, should, if possible, be preserved to prevent degeneration.

Tenotomy (Dupuytren, 1828), division of tendon for correction of deformity and contractures, should not be undertaken until the condition of the associated bones and soft tissues have carefully been considered. Tenotomy may be useless where an associated paralysis prevents any increase of function from the operation, or where bony changes prevent the correction of the deformity. If possible, tendon lengthening should be obtained by traction, as in the straightening of fingers contracted in flexion by elastic tension. *Tenoplasty* refers to a plastic operation upon tendons; *tenomyoplasty*, to a plastic operation upon muscles and tendons.

Rupture of tendons should be treated by *tenorrhaphy* or suture. The Frisch, Dryer, Stöffel, Bunnell, and Wilms' methods are useful, giving strength without strangulating the tissues. The reattachment of a tendon to a bone, *tenodesis*, is best accomplished by drilling the bone and fastening the tendon in the hole.

After the destruction of tendons, artificial tendons of silk thread impregnated with bichlorid of mercury (Lange) or, better, a tendon-transplant may be inserted.

OPERATIONS ON MUSCLES AND TENDONS

Muscle stripping is a method of relieving contractures and producing the effect of muscle or tendon lengthening by separating the area of attachment of a muscle from the bone and permitting it to shift to a new point of attachment; care being taken not to interfere with the nerves and blood-vessels which usually enter the muscle near the point of origin.

Stripping from the calcaneus is used for claw-foot, or *pes cavus*. The short plantar flexor muscles are separated from the periosteum of the calcaneus. Stripping the flexors of the hip for flexion contracture (*Soutter's operation*) is accomplished through a longitudinal incision running downward for 10 cm. from the anterior superior spine. The tensor fasciæ latæ and adjacent contracted muscles are stripped from the trochanter, the crest, anterior surface of the ilium to the anterior superior spine. In severe cases it may also be necessary to strip the psoas muscle.

For flexion contracture of the elbow the flexor muscles of the forearm are stripped from the medial condyle (Aberle).

These operations supply a realignment of muscle. In the after-treatment traction or fixation by plaster or splint is used to maintain the full correction. In cases of great contraction, graduated extension may be used after the operation until the correction is obtained.

Postoperative Treatment.—After *tenotomy* immobilization should be continued for three to six weeks; after *tenorrhaphy* movement is started in two weeks, and gradually increased weight bearing after the third week.

Special Operations on Tendons. Extensor Paralysis of the Wrist: The transplanted tendon should convey sufficient power not only to extend the wrist but also to abduct the thumb.

1. *Robert Jones' method* consists of transplantation of the flexor carpi radialis, pronator teres, and flexor carpi ulnaris to the extensors of the wrist and fingers. *Stiles' Modification:* The palmaris longus is united to the abductor pollicis longus and abductor pollicis brevis, the flexor carpi radialis to the extensors of the fingers and thumb. The pronator teres to the extensor carpi radialis longus and brevis, the muscles being swung around the radial border from the volar to the dorsal side.

2. *Stöffel's method* consists of the transference of the flexor carpi radialis to the extensor carpi radialis brevis, of the flexor digitorum sublimis to the abductor pollicis longus and extensor pollicis brevis, and of the flexor carpi ulnaris to the extensor digitorum communis and extensor pollicis longus.

An interosseus transplantation is undesirable (Steindler). After-treatment: Immobilization is continued in an over-corrected extended position for two weeks, after which movement and massage is started, a supporting splint being worn for six months.

Abduction paralysis of the thumb (*paralysis* or *destruction of the thenar muscles*) may be corrected by splitting the long flexor of the thumb, and anchoring one-half dorsally to the base of the proximal phalanx (Steindler).

Extensor Paralysis of the Fingers.—A musculospiral injury.—*Stöffel's operation:* The insertions of the dorsal interossei are transplanted to the dorsal side of the fingers, to give their tendons a dorsal course.

Tendinitis.—Inflammation of the tendon proper occurs chiefly in the tendo calcaneus in connection with rheumatism and gout; with pain, swelling and, at times, nodular thickening. The treatment is relaxation, support, protection from cold and strain, and appropriate internal treatment for the underlying condition.

DISEASES OF BURSÆ

Bursæ often communicate with contiguous joints, and infection of a bursa may be followed by septic invasion of the joint. From contusion a *bursal hematoma* may form, or from abnormal or repeated pressure a *new* or *adventitious bursa.*

Bursitis.—Acute: Follows single or repeated trauma, or acute local or hematogenous infection. The bursa is distended by fluid, hyperemic, swollen and tender on pressure.

Treatment.—Rest, relaxation of overlying muscles to avoid pressure, evaporating lotions, counterirritation, aspiration, injection of 1 or 2 c.c. of a 2 to 5 per cent. phenol or a 1 to 2 per cent. solution of quinin and urea hydrochlorid into the bursa. If the condition persists, or if suppuration recurs the bursa should be opened and packed with gauze or, better, excised.

Chronic Bursitis.—The bursa is enlarged, thickened, and distended by a yellowish or brownish, mucilaginous or gelatinous fluid (*bursal hydrops* or *hygroma*). From great thickening of the wall, the bursal cavity may be largely obliterated. Chronic suppuration may occur, with involvement of the overlying skin and abscess formation. Caseation occurs in tuberculosis. Fibrous fringes and bands may form. Loose bodies (*melon-seed bodies*) occasionally lie free in the sac; *tophi* of urate of soda form in gout.

Etiology.—Repeated traumatism, gonorrhea, rheumatism, gout, or focal infection, tuberculosis, syphilis. *Occupation* or *trade bursitis* is associated with certain forms of work, as "housemaid's knee."

Symptoms.—A tense, elastic, globular swelling at the normal situation of a bursa. Tenderness may or may not be present. The mass may be mistaken for a cyst, tumor, hernia, or aneurysm.

Treatment.—Aspiration, irrigation with a 5 per cent. phenol solution, or the injection of $\frac{1}{2}$ to 1 c.c. of tincture of iodin. For recurrent bursitis, a greatly thickened sac or, for suppuration, complete excision is the preferred treatment.

Calcaneal bursitis (*painful heel, stone bruise, policeman's heel*) may involve the anterior or posterior calcaneal bursa.

Posterior calcaneal bursitis (*achillobursitis, Albert's disease*, 1893) involves the retrocalcaneal bursa lying between the posterior surface of the calcaneus and the tendo calcaneus. There is tenderness and deep swelling over the superior part of the posterior surface of the calcaneus with pain on weight bearing with the foot dorsiflexed. The term *achillodynia* is also applied to a synovitis of the tendo calcaneus.

Another posterior calcaneal bursa, 1 or $1\frac{1}{2}$ cm. in diameter, lies on the periosteum over the tuberosity of the calcaneus, at the point where the chief weight comes in standing. Anterior to this bursa, and over the aponeurosis of the short flexor, is an inconstant smaller bursa, the midcalcaneal bursa. The anterior calcaneal bursa lies between the short and long flexor tendons that pass upon the sustentaculum and, when inflamed, is often associated with an exostosis beneath the middle of the sustentaculum tali or upon the medial process of the tuberosity.

Etiology.—Trauma, exposure, gonorrhea, scarlet fever, gout, or rheumatism.

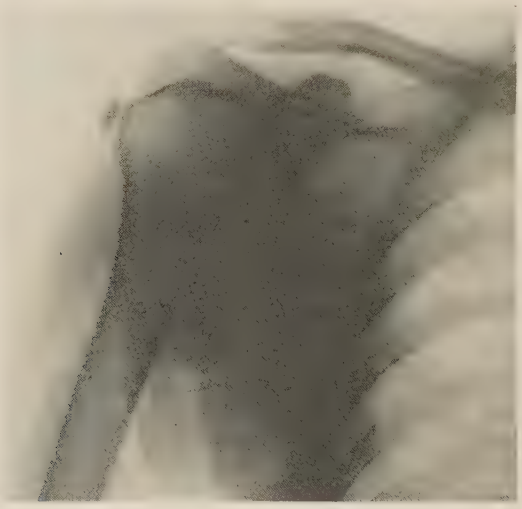


Fig. 236.—Subdeltoid bursitis with calcification. (Roentgenogram by Dr. G. C. Bird.)

Symptoms.—Pain on dorsiflexion of the foot and as the heel strikes the ground, to relieve which the patient may walk upon the toes. Pain may also be felt over the midplantar region, the dorsum of the foot, in ankle, calf, or thigh. There may be local tenderness over the insertion of the tendo calcaneus or deltoid ligament, or over the tuberosity or the plantar or medial surface of the sustentaculum according to the bursa inflamed. One or more bursæ may be involved.

Treatment.—Rest and elevation of heel to produce an equinus position; aspiration, and injection of 2 per cent. phenol into bursa. Incision, and packing for twenty-four hours with gauze soaked in 3 per cent. tincture of iodin. For the posterior bursa Hertzler uses a 1-inch incision just over the medial tubercle, the bursa being removed by a sharp curet, and the wound packed, for one day, with gauze soaked in a 3 per cent. tincture of iodin. For the anterior bursa,

an incision along the medial border of the foot just beneath the sustentaculum, the bursa superficial to the long flexor tendons and beneath the origin of the adductor pollicis is removed by a curet, and a one-day packing applied.

Anterior plantar bursitis (*metatarsal neuralgia, metatarsalgia; Morton's disease*, Morton, 1876), first ascribed to a neuritis, is considered a bursitis by Hertzler. The metatarsophalangeal bursæ lie between the metatarsophalangeal joints of adjacent toes, forming sacs about 1 cm. in diameter not connecting with the joints or adjacent tendons. For patients not relieved by support to the anterior arch of the foot, Hertzler advises that an incision be made on the dorsum, the bursa freely curetted, and the cavity packed for twenty-four hours. The patient is permitted to go about after one week.

Subdeltoid or **subacromial bursitis** follows trauma, gout, rheumatism, syphilis, and tuberculosis.

1. *Acute:* Pain is referred to the insertion of the deltoid, radiating into the neck or arm or hand, occurring on voluntary but not on passive movements, being worse at night. On voluntary abduction or external rotation of the arm the scapula becomes locked, as by muscular spasm, to the humerus. There is tenderness, just below the acromion and lateral to the bicipital groove, which disappears when the arm is abducted (Dawbarn's sign) from the bursa slipping under the acromion. Swelling may not be evident.

Fig. 237.—Syphilitic bursopathy of Vernieul (collection of Dr. John E. Lane). Bilateral prepatellar bursitis; with the left knee the gummatous infiltration has broken down and discharged (Stokes).

2. *Subacute:* Associated with adhesions within the bursa, limiting abduction and external rotation. Tenderness remaining when the arm is abducted. The condition may persist for one or more years.

3. *Chronic:* Associated with irregular thickening of the bursa, with pain on abduction when the tuberosity of humerus slips beneath the acromion; pain may be intermittent.

Diagnosis from inflammation of the sheath of biceps is made by the local tenderness with relation to abduction. Acromioclavicular arthritis is associated with thickening and tenderness of the joint. Abscess causes fixation of the shoulder. Fracture and tuberculosis of the humerus are differentiated by the local swelling, deformity, and Roentgen study.

Treatment.—(1) Correction of any existing diathesis; (2) abduction or airplane splint in the acute forms; (3) later, passive motion, diathermy; (4) injection of a 2 to 5 per cent. solution of phenol into the bursa. Subacute forms are treated by massage, passive, and active movements; baking, diathermy, rupture of adhesions under an anesthetic, or excision of subdeltoid portion of bursa. A vertical, 8 cm., incision is made over the external lip of the bicipital groove, separating the fibers of the deltoid; and the bursa opened while downward traction is made on the arm. Thickened capsular exostoses are removed, and the lower

portion of the bursa excised. The arm is dressed in abduction, and passive motion started early.

Other bursæ that may become inflamed and require treatment along similar lines are: (1) *Prepatellar bursa* (*housemaid's knee*), (2) *olecranon bursa* (*draftsman's* or *miner's elbow*), (3) *ischial bursa* (*weaver's* or *waterman's bottom*), femoral condylar bursa, or *ganglion of popliteal space.* (4) Over the head of first metatarsal bone in hallus valgus (*bunion*). (5) Between tendon of biceps and tuberosity of radius. (6) Over the lateral malleoli (*tailor's ankle*). (7) *Iliopsoas bursa*, between the psoas muscle and anterior capsule of hip-joint, which may be mistaken for psoas abscess or femoral hernia. (8) *Subcrural bursa*, beneath the quadriceps, usually communicating with the knee-joint. (9) *Popliteal*, between semimembranosus and medial head of the gastrocnemius. (10) *Acromial*, an adventitious bursa over the acromion. (11) *Subscapular*, an adventitious bursa under the subscapularis.

Tumors.—Fibroma, myeloma, giant-cell tumor, or sarcoma may spring from bursæ and should be excised or radiated.

CHAPTER XIX

THE BLOOD-VESSELS

DISEASES OF ARTERIES

Simple plastic or **traumatic arteritis** results from contusions and aseptic wounds of arteries, and is characterized by proliferation of the intima, exudation from the vasa vasorum, thrombosis, and conversion of the vessel into a fibrous cord, which in some cases is later channeled. It is a reparative process.

Septic arteritis follows infection from a septic wound, a ligature, or the extension from an adjacent or distant infectious process (abscess, ulcer, bacteremia, embolism).

Pathology.—The arterial coats are inflamed, softened, and disintegrated by the action of bacteria and their toxins. A thrombus forms within the vessel which may liquefy with suppuration, so that secondary hemorrhage or embolism follows.

Embolic arteritis.—An embolus, usually from a malignant endocarditis, obstructs one of the smaller arteries with secondary embolism, acute softening of the arterial wall, aneurysm, infarction in the lungs, spleen or kidney, or gangrene in the intestinal tract or extremities. The lodgment of a septic embolus is followed by local suppuration, solution of the arterial wall, and abscess formation.

Arteriosclerosis (*atheroma*) is a chronic endarteritis, with proliferation of cells in the deeper layer of the tunica intima, obstructing the vasa vasorum so that fatty degeneration or atheroma of the deeper layers of the intima and of the media occurs. The areas involved become impregnated with lime salts, forming slightly raised yellowish patches or plaques on the intima.

Secondary softening (*atheromatous abscess*) is followed by rupture into the lumen of the artery with formation of atheromatous ulcers. Secondary calcification and thickening of the tunica adventitia occurs, the artery finally becoming rigid, corrugated, and pipe-stem like. Weakening of the vessel walls and loss of intima are followed by rupture (*hemiplegia*, *dissecting* and *false aneurysm*), thrombosis, atheromatous obliteration, secondary degeneration of parts supplied by the vessel, and gangrene. True aneurysm is uncommon, except from syphilitic arteritis.

Obliterative Endarteritis.—A proliferation and thickening of the intima, the elastic lamina remains unchanged, there is a formation of granulation tissue with organization and fibrosis, and progressive thickening that obstructs the lumen.

Symptoms.—There is coldness, numbness, and, at times, gangrene of the parts supplied. Pain, especially in cold weather.

Diabetic endarteritis is often an obliterative endarteritis with atheroma, calcification, and thrombosis. Usually the anterior and posterior tibial and

popliteal arteries are obliterated in diabetic gangrene, rendering it necessary to amputate above the knee.

Thrombo-arteritis Obliterans (*Thrombo-angiitis obliterans*) (Buerger's Disease, 1908).—A chronic hyperplastic thickening of the coats of arteries, with formation of thrombi in the lumen of the vessel, which become organized. It chiefly involves vessels of legs, or less frequently the arms, with intense pain and a marked tendency to gangrene. Adult male Hebrews and Japanese, who are heavy cigarette smokers, form an overwhelming majority of the patients. The veins are also involved.

Treatment is described on page 107.

Periarteritis nodosa (Kussmaul and Maier, 1866) is characterized by inflammatory nodes of toxic or infectious origin, in the adventitia of arteries,

Fig. 238.—Superficial gangrene of index-finger from peri-arteritis obliterans. Recovery without loss of the finger followed division of the thickened adventitia of the radial artery.

with involvement also of intima and media. The formation of granulation tissue, destruction of elastic membrane, formation of cicatricial tissue, and obstruction of the arterial lumen follow. The condition results in hemorrhage, arterial dilatation, and arterial obstruction.

The **symptoms** are neuralgic or myalgic pain, abdominal colic, and vasomotor spasms. The pain may be taken for appendicitis, cholecystitis, peptic ulcer, or pancreatitis. Petechiæ and ecchymotic hemorrhages occur.

The **prognosis** is unfavorable, the condition usually being fatal within a few months, chiefly from atrophic nephritis and uremia.

Syphilitic arteritis includes: 1. *Mesarteritis*, found in aorta and other large arteries with: (a) Perivascular infiltration of vasa vasorum, extending into media. (b) Infiltration of media with plasma-cells. (c) Degeneration of muscle with fibrosis and contraction, producing short linear or stellate scars.

The overlying intima may degenerate and calcify (syphilitic atheroma). The weakening of the supporting media makes this form of arteritis the most common cause of aneurysm.

2. *Obliterative endarteritis*, which occurs in smaller arteries and about gummas, with proliferation of cells and thickening of the intima within the elastic lamina, and a tendency to the formation of granulation tissue, fibrosis, and obliteration of the lumen. Similar changes occur in tuberculosis.

Fig. 239.—Gangrene of toes and part of foot from thrombo-angiitis obliterans.

3. *Periarteritis.*—The adventitia is at first infiltrated and thickened, and later becomes hyaline and fibrotic. The intima may also be thickened, with occlusion of lumen. The condition is characteristic of syphilis of the central nervous system, producing white softening of the brain.

Tuberculous endarteritis is characterized by obliteration of the smaller vessels, with proliferation of the intima, and secondary caseous degeneration. Secondary hemorrhage may result.

In the walls of tuberculous cavities small aneurysmal dilatations may occur.

The **treatment** of syphilitic and tuberculous arteritis is largely that of the underlying diseases. Ligation or packing may be required for hemorrhage.

ANEURYSM

Definition.—An abnormal, circumscribed, blood-containing cavity, communicating with an artery. An aneurysm consists of a sac, neck, and contents. The contents include liquid blood, coagula, and laminated fibrin. Aneurysms vary in size from that of a millet seed to a child's head. They may be single or multiple. In the order of frequency they involve the thoracic aorta, popliteal artery, femoral artery, abdominal aorta, subclavian artery, innominate artery, axillary artery, iliac artery, and the cerebral and pulmonary arteries.

Varieties.—1. **Congenital:** Congenital aneurysms are extremely rare, and involve the abdominal aorta and ductus arteriosus (Botalli). A rare congenital deficiency of the elastic elements of the walls of the arteries of the body may be the cause of multiple aneurysms, especially of the smaller arteries.

2. **Idiopathic aneurysms** are those arising without obvious traumatic injury to the vessel wall. They are usually dependent upon syphilitic arteritis, and constitute most of the aneurysms involving the great vessels of the trunk, and also the smaller aneurysms of the brain and other viscera.

Fig. 240.—Aneurysm of the external iliac artery.

3. **Traumatic aneurysms** are those resulting from mechanical injuries sustained by the arterial wall, either in the form of contusion, incision, or laceration. The injured artery may merely stretch, forming a *circumscribed traumatic aneurysm;* or it may rupture or be divided, when the blood distends the adjacent tissues, separates the fascial planes, and forms a *diffused traumatic aneurysm.* A *circumscribed traumatic aneurysm* may also result from the yielding of an old arterial scar or a partially divided vessel wall.

4. **Hernial aneurysms** are small traumatic aneurysms, produced by the bulging of the inner tunic through the separated outer layers of the arterial wall.

5. **True aneurysms** are those having walls formed by the normal coats of an artery. It is rare, however, to find an aneurysmal sac in which intima, elastic layer, media, and adventitia can all be demonstrated.

6. **False aneurysms** are those in which the sac is formed by tissues other than those derived from the wall of the artery. They follow arterial incisions or ruptures, but even in these false sacs the endothelium proliferates from the intima of the artery, and tends to line the sac.

7. **Diffused aneurysms** are false aneurysms resulting from an extensive extravasation of blood from an artery. As a rule they are due to traumatism, but they also result from the spontaneous rupture of a diseased artery or aneurysm.

8. **Dissecting aneurysms** (Shekelton's aneurysms) are those in which the sac lies between the coats of the artery. As a rule they have two mouths, the blood entering through one opening separating the layers of the arterial wall, and then, at some distance, recommunicating by a second opening with the arterial stream. These occur most frequently in the abdominal aorta, and may produce a very extensive separation of the arterial coats.

Fig. 241.—Gangrene of the foot two weeks after division of the upper part of the popliteal artery by a bullet. (Case 27, Surg. Hist., War of Rebellion.)

9. **Embolic aneurysms** are those resulting from the lodgment of emboli. They are attributed by some to the laceration of the walls of the small vessels by calcareous embolic particles. It is evident that they may also result from degenerative or inflammatory changes of the arterial wall, secondary to the lodgment of the embolus.

10. **Miliary aneurysms** are very minute, and are most frequently observed in the brain or lungs. They involve the small or medium sized arteries, and often occur in great numbers.

11. **Verminous** or **worm aneurysms** occur in the mesentery of the horse from the larvæ of the *Strongylus armatus*.

12. Arteriovenous aneurysms are produced by an abnormal communication between an artery and a vein. They include *aneurysmal varix*, in which a dilated varicose vein communicates directly with the artery, and *varicose aneurysm*, an aneurysm communicating with a vein as well as an artery.

Fig. 242.—Large aneurysm of the arch of the aorta. Rupture, with instant death, occurred later, while the patient was in a physician's office. (Roentgenogram by Dr. G. C. Bird.)

Closely related to aneurysms is *arterial varix* or *cirsoid aneurysm* (analogous to a varicose vein), in which an artery, usually of the scalp, is tortuous and much dilated for a considerable distance. *Aneurysm by anastomosis* or *plexiform*

Fig. 243.—Circumscribed traumatic aneurysm of the lower part of the radial artery following an incised wound.

aneurysm is a condition characterized by a mass of communicating large arteries which may be classed with the blood-vessel tumors.

Aneurysms are divided according to shape, into (1) the *ectatic* or *axial*, in which the entire circumference of the artery is rather uniformly dilated for a

considerable distance, forming a fusiform, tubular, or cylindrical aneurysm; and into (2) the *sacculated* or *lateral*, in which only a part of the circumference of the artery is involved in the formation of the sac.

Etiology.—Aneurysms result from conditions which weaken the arterial wall and increase the blood-pressure.

Race.—The Anglo-Saxon race is most frequently effected, the English more than the American, a condition attributed to the greater consumption of alcohol in England. Aneurysm is rare in the Asiatic races and in Italy. It is three times as prevalent in the American negro as in the white race, probably due to the great incidence of syphilis in the blacks.

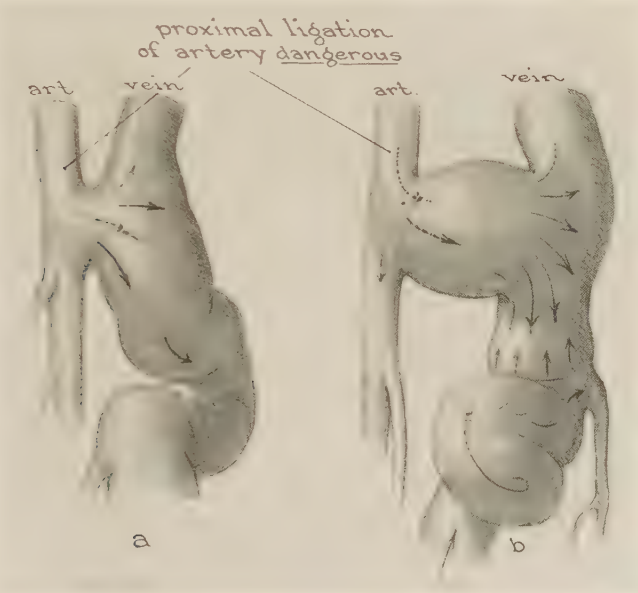


Fig. 214. Arteriovenous communication with the production of aneurysmal varix: *a*, *b*, Varix distended by the arterial blood-pressure.

Age.—Aneurysm is most frequent between the ages of thirty and fifty, a period when degenerative changes in the arteries are frequently found.

Sex.—Men are affected ten times as frequently as women, with the exception of the dissecting and carotid forms of aneurysm, which occur more frequently in women. The more laborious occupations of men and their greater tendency to dissipation and excess explain the influence of sex.

Occupation.—Soldiers, sailors, athletes, cab-drivers, furnace men, and others engaged in violent but intermittent exercise (especially the intemperate and syphilitic) are especially predisposed to aneurysm. It is eleven times more frequent in the English soldier than the civilian. It is more frequent in soldiers than in sailors, a condition attributed to the pressure and strain from poorly fitted clothing and heavy accoutrements. The older cab-drivers, so often dissipated and syphilitic, were especially subject to thoracic aneurysm, apparently due to the pull upon the arms.

Activity.—Vessels especially subjected to repeated flexion and extension and, therefore, increased wall pressure (as the popliteal and iliacs), or under greater strain, as those of the right arm rather than the left, are more often involved. Occasionally symmetrical aneurysms occur, such as bilateral popliteal aneurysms.

Disease.—Syphilitic aortitis is the predominant cause of non-traumatic aneurysm.

Other conditions that produce a weakening of the arterial wall—including tuberculosis, alcoholism, rheumatism, gout, mineral poisons (such as lead), cardiac hypertrophy, plethora, and renal disease—are rarely responsible for aneurysm. General arteriosclerosis is not commonly associated with aneurysm.

Emboli, especially infected emboli, favor aneurysmal dilatation of the arteries in which they lodge.

Mycotic aneurysm due to the invasion of the arterial wall by micro-organisms, causing aneurysmal dilatation which may be followed by rupture, occurs in the terminal arteries in tuberculous cavities (*Rasmussen's aneurysm*).

Traction aneurysms are small aneurysms which develop in the aorta from the traction of an incompletely obliterated ductus arteriosus.

Pathology.—An area of the muscular coat, degenerated from atheromatous or other change, expands with systole and does not fully contract with diastole. The diseased arterial wall slowly balloons out on one side (sacculated) or circumferentially (fusiform). A sacculated aneurysm often begins as a fusiform dilatation.

The weakened arterial walls greatly distend under the force of the blood-pressure. In sacculated aneurysm the inner and middle coats of the artery may be partially absent from the walls of the sac, only the lining endothelium and the adventitia being present.

In an ectatic aneurysm all the layers of the arterial walls may remain, and the wall of the sac be thicker than that of the normal artery. The intima may be thickened by atheroma, the adventitia by the deposit of fibrous tissue, and the middle coat be very thin.

As the inner coats of an artery constitute not less than three-fourths of the thickness of the wall, and contain the elastic and muscular layers and the vasa vasorum which supply the walls with nourishment, the thinning or absence of these structures means a weak, impoverished wall for the aneurysmal sac. In sacculated aneurysms there is usually a progressive deposit of layers of fibrin against the wall of the sac, tending to strengthen the walls and lessen the fluid contents.

The lessening of the fluid contents is important, the pressure on the sac wall varying as the square of the diameter of the cavity which contains the fluid.

At times the blood-clot is deposited in progressive layers until the entire sac is filled, resulting in a spontaneous cure. The blood-clot at the periphery is white, laminated, and fibrous, although rarely organized into true fibrous tissue, the lack of vasa vasorum preventing vascularization. Within the laminated clot is a layer of softer red blood-clot, and finally fluid blood communicating with the blood-stream. The aneurysm, therefore, consists of a sac or body, which in the sacculated form may communicate by a neck and mouth with

the artery. The sac is strengthened on the outer side by the deposit of fibrous tissue, an evidence of the reaction and irritation of the tissues against which the aneurysm presses.

In the cylindrical fusiform aneurysms little or no lining clot is present.

An aneurysm influences the blood-stream, absorbing the cardiac waves, so that the pulse distal to the sac is delayed and weakened. To compensate for this the heart may hypertrophy and anastomotic channels form. The aneurysm may so press upon the main arteries and veins, including the artery from which it starts, as to completely interrupt the circulation. The adjacent tissues are variously affected. Bone is eroded and progressively destroyed by the continuous pressure, cartilage being much more resistant than bone. Nerves are stretched, compressed and flattened, and at times destroyed, giving rise to paresthesia and, more rarely, paralysis. Adjacent veins cause cyanosis and edema when compressed, or, rarely, are eroded and perforated. Mucous canals are compressed and displaced, while fibrous tissue, tendons, and fasciæ are flattened, stretched, and often incorporated into the sac. Thrombi may form in tributary vessels, and emboli may result from the dislodgment of clot or fibrin, causing cerebral complications (such as hemiplegia), infarcts in the internal organs, and gangrene of the extremities.

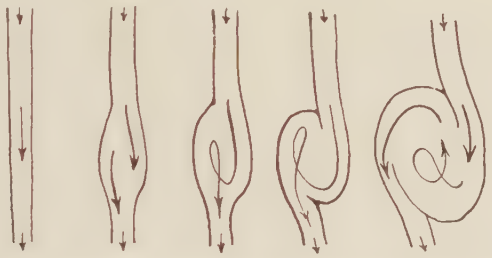


Fig. 245.—The rotation of an enlarging aneurysm with movement of the orifices of vessels entering into the sac.

The size and shape of the sac is modified by adjacent pressure. Rotation of the sac may occur, so that, in a fusiform aneurysmal sac, the orifices of the afferent and efferent trunks may lie at the sides or equator of the sac (or even be reversed) rather than at their respective poles. Matas classifies aneurysms by the number of orifices which connect them with the parent artery. These orifices are accurately determined only after opening the sac. Fusiform aneurysms have two distinct orifices. Saccular or sacciform aneurysms are those which are connected with the lumen of the parent vessel by a single circular, ovoid, or elongated opening, through which the blood flows in and out of the sac. The sac of the aneurysm may have many collateral branches, corresponding somewhat with the branches normally given off by the segment of the arterial wall forming the aneurysm. These collaterals may be functional or impervious, containing thrombi. The perianeurysmal circulation may be very important in maintaining the collateral circulation after operations upon the sac.

Symptoms.—The chief symptoms of aneurysm are the presence of an expansile, pulsating tumor, a peculiar bruit (*aneurysmal bruit*) heard over the

swelling, retardation and weakening of the pulse distal to the aneurysm, and pressure symptoms, consisting of pain and paralysis from pressure on nerves and absorption of contiguous parts.

1. **Tumor.**—An aneurysm forms a smooth, rounded, or oval enlargement in the course of an artery. It is not sensitive unless inflamed, and is not adherent to the overlying skin, but may be associated with edema and venous congestion of the parts distal to the tumor. The swelling has an expansile pulsation up to the time that a sufficiently thick layer of clot has formed within the sac to abolish this sign, so that the symptoms are at times divided into those of the (a) *expansile* and (b) *non-expansile* stage. The expansile pulsation may be less marked, and the tumor softer with the part elevated. The pulsation is diminished by pressure upon the main artery proximal to the aneurysm and, in some cases, the sac may then become softer.

2. **Bruit** (Paré, 1582).—On auscultation a systolic or, sometimes, a double rough murmur or *aneurysmal bruit* is heard, loudest at the proximal pole. The bruit is often palpable. In small aneurysms it resembles the buzz of a bumble bee or blue-bottle fly. A diastolic shock, felt at the aortic cartilage (*Sibson's sign*), is more frequent in thoracic aneurysm than in hypertension.

3. **Pulse** is retarded, weak, or absent in the artery distal to the sac.

4. **Pain** is felt in the area of the aneurysm or referred to distant parts.

Subjective symptoms include pain from the stretching and compression of nerves, and the arrest of the venous or lymphatic circulation. In the skull, a rushing sound and bruit, headache, and the evidences of cerebral pressure or irritation—such as choked disk, vomiting, dilated pupil, motor and sensory disturbances, and localizing nerve palsies—may be present.

Pressure symptoms result from: (a) *Pressure on nerves*, with numbness, pain, and loss of power; as of the recurrent (laryngeal) nerve, with hoarseness, rasping voice, and brassy cough; the phrenic, with hiccup and dyspnea; the vagus, with spasmodic dyspnea and cardiac irregularity; the intercostal nerves, with peripheral neuralgia; the cervical sympathetic, with dilated or contracted pupil, unilateral sweating and flushing of the face. (b) *Pressure on the trachea*, with dyspnea; (c) *on the esophagus*, with dysphagia, aphagia; (d) *on veins*, with edema and distention of superficial veins; (e) *on bones*, with severe, constant, boring pains—so-called osteocopic pains, which are worse at night, and are due, in thoracic aneurysm, to erosion of bodies of the vertebræ, the sternum, or the ribs.

Tracheal tugging (*Oliver's sign*), often found in aneurysm of the arch of the aorta, is due to the transmission of the aneurysmal pulsations to the left bronchus, and is detected by inclining the head forward and lifting the larynx and trachea by the finger and the thumb placed under the hyoid bone. Inanition may follow in the rare instances in which the thoracic duct is compressed. In thoracic aneurysm the distal vessels show a retarded and reduced pulsation, so that the pulse may be weak or even absent from the one wrist. Rupture is signalized by pain of sudden onset, with shock. The blood may escape internally, or externally through the skin, into the trachea, or into the alimentary canal. If it escapes into the pericardium, there are evidences of acute heart compression; if into the cavity of the thorax, of hemothorax; and if into

the muscular substance, the formation of a progressively enlarging tumor. The rupture may be immediately fatal, or the patient may live for hours or days.

Differential Diagnosis.—The expansile pulsation, bruit, and retardation of the distal pulse are fairly characteristic symptoms of aneurysm. In a consolidated aneurysm, or one in which the sac has been filled by clot, these signs may disappear. The history and the presence of a firm mass in the line of a large artery are suggestive. Tumors and abscesses lying upon arteries may have a heaving pulsation, but the expansile type of pulsation is absent. When the skin over an aneurysm has become inflamed the condition may so closely simulate an abscess that many have been lanced. Before consolidation occurs, compression of the main artery proximal to the aneurysm produces a characteristic collapse of the sac, and a cessation of pulsation and bruit. These changes cannot be produced in vascular sarcomas and other tumors, which may simulate aneurysms. In aneurysms of the thorax a Roentgen-ray examination is often diagnostic. In suspected aneurysm of the abdominal aorta loss or retardation of the femoral pulse should especially be looked for. The marked pulsation of the undilated aorta in thin persons should not be mistaken for aneurysm.

Caution: In determining the compressibility of the aneurysmal sac the *greatest gentleness must be employed.* We have observed hemiplegia to follow promptly the examination and palpation of a carotid aneurysm, from the dislodgment of particles of contained clot.

Prognosis.—Aneurysms tend to dilate progressively, and finally to rupture. In rare instances an aneurysmal sac may remain stationary for many years, finally again progressively to dilate. In a third class spontaneous cure occurs by a plastic arteritis and the coagulation of blood, which may completely consolidate the sac, with or without obliteration of the arterial lumen. Any condition which interrupts or retards the circulation through the sac may favor this spontaneous cure. This termination is very rare, and is at times followed by gangrene from an insufficient collateral circulation. Rupture may occur through the skin, mucous membrane, into a serous or synovial cavity, or into the subcutaneous tissues, muscles, or fascial planes. A rapid hemorrhage, sufficient to cause almost instant death, may occur; or a "leaking aneurysm," diffused aneurysm with repeated moderate hemorrhages, or one or several large hemorrhages, and progressively increasing hemorrhagic edema often followed by gangrene or death. Rarely does recovery follow after the rupture of an aneurysm of one of the great vessels of the trunk, although the patient may survive for days or weeks. Death in the sacculated type is usually due to rupture. Death in the fusiform type is usually due to pressure on a vital structure.

Treatment.—Medical: Dietetic, hygienic, and medicinal measures have been used for many years to retard the circulation and stimulate coagulation so that a clot would fill the sac. In the *ancient method of Valsalva* absolute physical and mental rest was enforced, with a very limited diet, the deprivation of fluid, and repeated venesection, continued until the patient was too weak to lift a hand. *Tuffnell's treatment* was less severe, although rigorous, and consisted of absolute rest in a horizontal position for at least three months, and a reduction in the diet to 2 ounces of bread and butter and 2 ounces of milk for

breakfast, 3 ounces of bread and butter with 4 ounces of water or claret for dinner, and 2 ounces of bread and butter with 2 ounces of tea for supper. A fat diet has been advised by Powell, and the use of meats has been condemned. Drugs are employed to reduce the cardiac frequency, diminish the arterial tension, and increase the coagulability of the blood. Potassium iodid has been considered the most valuable, being administered, according to the degree of tolerance, in doses of 1 gm. three times a day, and increased until 4, 8, or even 12 gm. are given. It is especially valuable in syphilitic patients, to whom salvarsan should also be cautiously given. Gelatin (Lancereaux and Paulesco) is difficult to sterilize, and has caused tetanus. It was

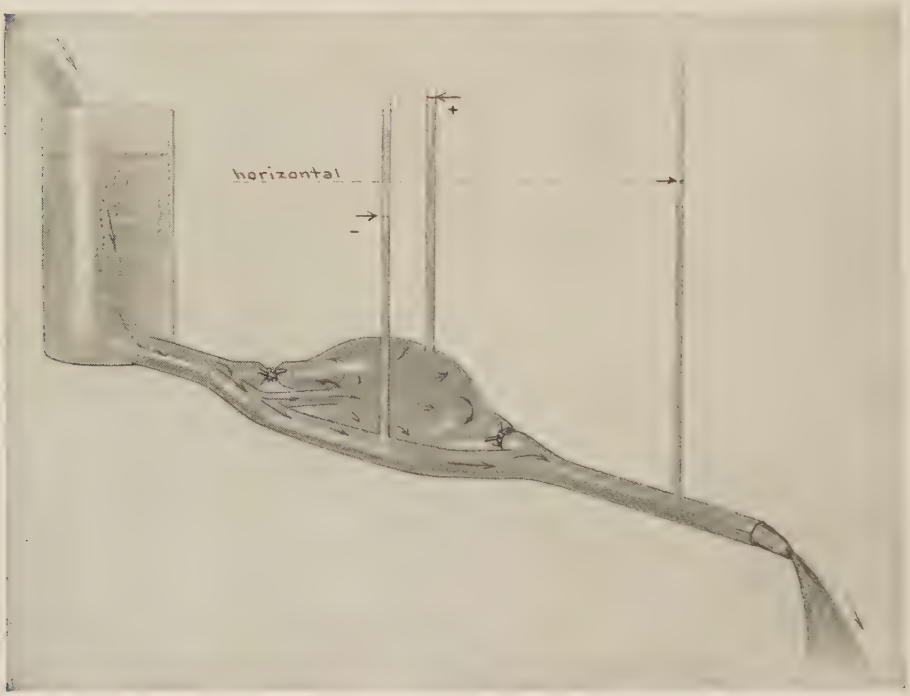


Fig. 246.—The effect of proximal and distal ligation of the main vessel for aneurysm—blood still enters the sac through a collateral vessel and the intersaccular pressure is increased.

formerly injected subcutaneously, like horse-serum, to increase the coagulability of the blood. Calcium chlorid, injected intravenously (5 c.c. of a 10 per cent. solution), has also been used.

I. **Local Measures.**—*Obsolete, dangerous, and usually ineffectual methods:* A. *Proximal arterial compression* by: (a) Thumbs of relays of assistants applied continuously or intermittently for from thirty-six to seventy-two hours; (b) pads or tourniquets or Esmarch's bandage to arrest the circulation for ninety minutes; (c) forced flexion of the knee or elbow over a pad or soft-rubber ball.

B. *Distal* and *proximal compression* of the artery above and below by Esmarch bandages for two hours. These methods are painful, usually ineffectual, and may be followed by sloughing, gangrene, or other complications.

C. *Manipulation* of sac to dislodge an occluding thrombus is very dangerous.

D. *Injection of coagulants* into the sac.

E. *Partial or Complete Arterial Occlusion.*—1. *Proximal Ligation:* (a) Close to sac (Anel, 1710); (b) at a distance from the sac with several non-occluding ligatures (John Hunter, 1785).

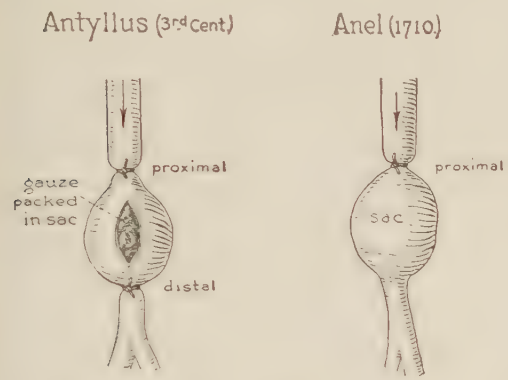


Fig. 247.—Ancient methods of ligation for aneurysm of Antyllus and Anel. Antyllus' method of treating aneurysm by proximal and distal ligation and packing of the sac, and Anel's method by proximal ligation.

Fig. 248.—John Hunter's operation for popliteal aneurysm by proximal ligation at a distance in Hunter's canal.

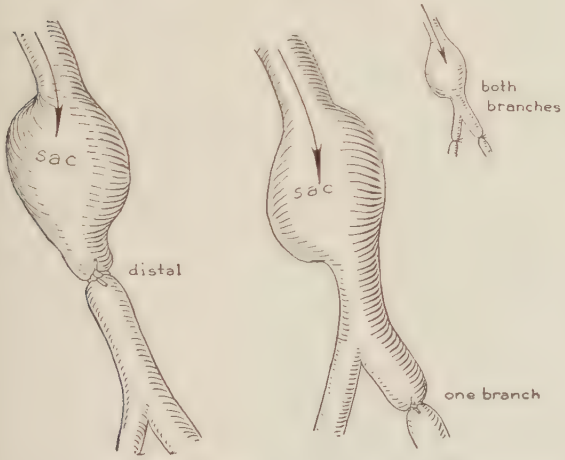


Fig. 249.—Older methods of ligation for inaccessible aneurysms: Distal ligation of Brasdor, distal ligation of one or both distal branches of Wardrop.

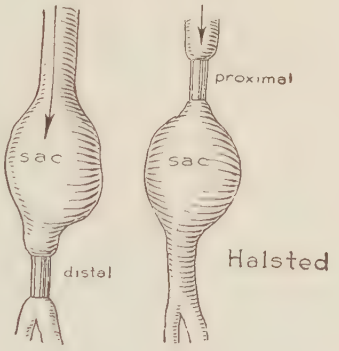


Fig. 250.—Halsted's method of treating aneurysm by proximal or distal application of an aluminum band to reduce the caliber of the artery. Experience has shown the method to be ineffective.

2. *Distal Ligation:* (a) of the main artery (Brasdor, 1721–1797); (b) of a branch of the main artery (Wardrop, 1827), used for aneurysms of the arch of

the aorta and the innominate artery, to slow the current and favor clotting in the sac.

3. *Proximal and distal ligation* of the main artery, and possibly of the branches.

4. *Proximal or distal partial occlusion* by coiled aluminum band (Halsted) or other device.

These occlusive methods, while they may slow the current and favor coagulation in the sac, are hydrodynamically unsound and tend to increase intrasaccular tension, due to the law that "the pressure upon the wall of a tube containing a moving liquid is increased by reducing the velocity of the current." The occlusion has frequently been followed by dilatation and rupture of the sac, and by aneurysmal dilatation proximal to the point of occlusion. The degeneration and giving way of the sac wall is also favored by the impaired circulation in the vasa vasorum.

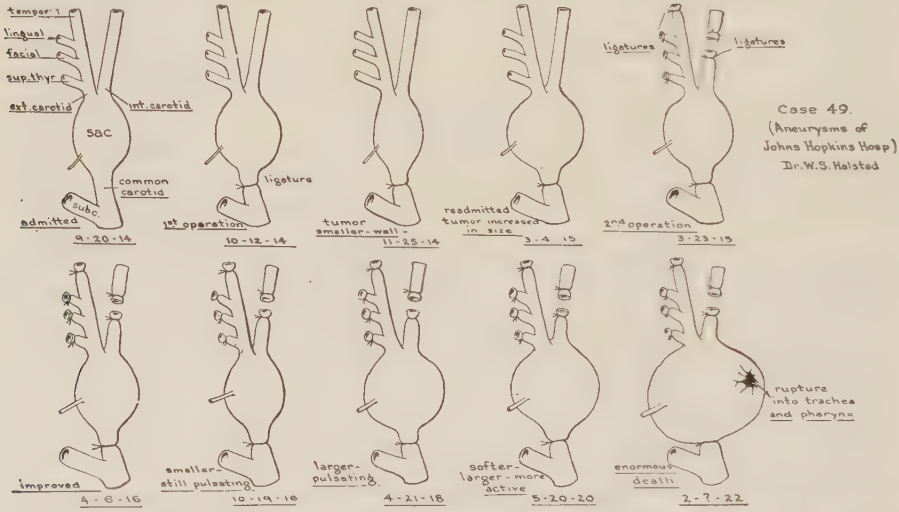


Fig. 251.—Aneurysm of the common carotid artery treated by repeated ligation by Dr. Halsted, illustrating the inefficiency of the treatment by ligation for many aneurysms.

F. *Introduction of substances within the sac* to stimulate coagulation, chiefly used for thoracic and other inaccessible aneurysms. (1) *Galvanopuncture* of the sac (Philetus, 1829; Petroquin, 1831). (2) *Needling*—one or more needles passed into the sac (Velpeau). (3) *Scarification* of lining of the sac by the introduced needles (Macewen). (4) *Wiring*, the *introduction of a coil*, to stimulate coagulation and hold coagula: (a) Iron wire (Moore); (b) watch-spring (Bacelli); (c) horse-hair (Levis, 1876); (d) wiring through a fine needle with galvanism (Moore-Corradi method, 1864–1879). Wiring not infrequently relieves pain, but has a high mortality. Over 50 per cent. of the patients thus treated have died within two months, and few have lived a year after wiring and electrolysis. Rupture, suppuration, and embolism have caused most of the deaths.

Technic of Moore-Corradi Method.—Local anesthesia is used for a thoracic aneurysm, and general anesthesia and laparotomy for an abdominal aneurysm. A long hypodermic needle, insulated to

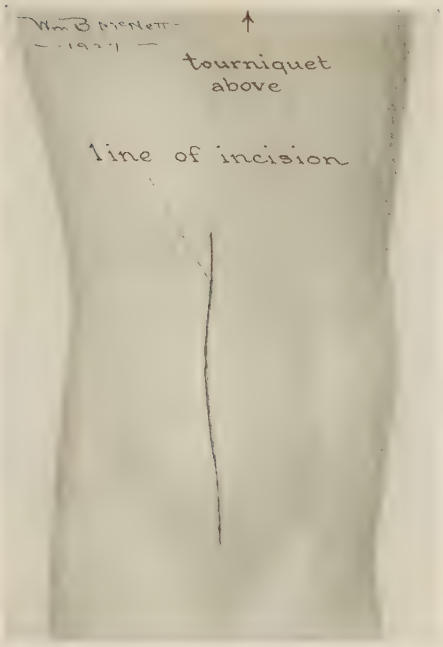


Fig. 252.—Matas' obliterative operation for popliteal aneurysm: Line of incision.

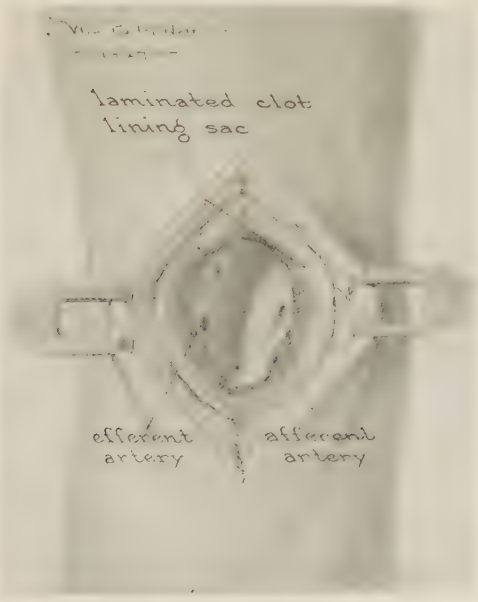


Fig. 253.—Matas' obliterative operation for popliteal aneurysm: Sac opened, showing the opening of vessels and the lining of laminated clot.

5 mm. of the point, is used. The non-insulated part must not touch the skin, or it will cause an electric burn. Gold, silver, or gilded wire, annealed by heat and wrapped on a reel, should be used. The needle is introduced into the sac of the aneurysm, and 300 cm. of wire is passed into a sac 18

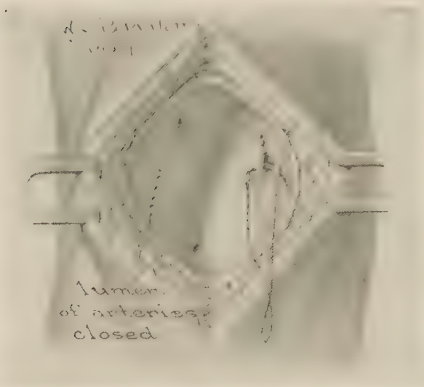


Fig. 254.—Matas' obliterative operation for popliteal aneurysm: The laminated clot has been removed and all vascular openings into the sac are being closed by suture.

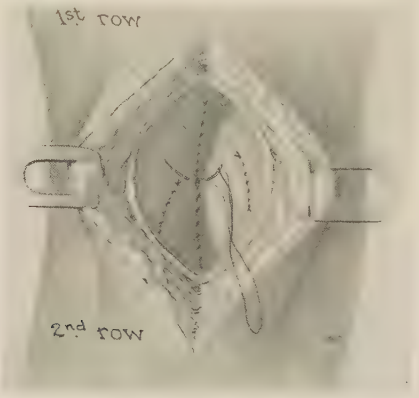


Fig. 255.—Matas' obliterative operation for popliteal aneurysm: Obliteration of the sac by rows of plicating suture.

Fig. 256.—Matas' obliterative operation for popliteal aneurysm: Obliterative closure of the sac.

cm. in diameter. The wire is attached to the positive pole of the battery, the negative pole to a large electrode under the back, and the current is gradually increased to 40 to 80 milliamperes, continued about one hour, and then gradually turned off. The wire is cut close to the skin, and the

end pushed into the sac. The needle is withdrawn and the puncture sealed, pressure being applied to control oozing. The patient should rest in bed for several months after the wiring, unless, as often happens, death occurs.

Fig. 257.—Aneurysm of the lower end of the brachial artery following gunshot injury.

II. Curative Operations for Accessible Aneurysms.—A. *Antyllus' Operation* (third century): (1) Circulation is controlled by compression proximal to the sac; (2) the sac is opened and emptied of the clot; (3) the artery is ligated above and below; (4) the sac is drained and packed.

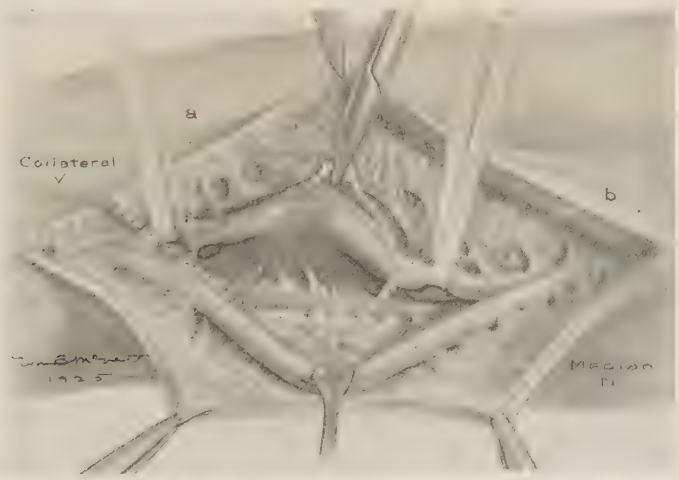


Fig. 258.—Traumatic aneurysm of the brachial artery: Liberation of the aneurysm. Tapes for hemostasis in place under the vessel.

B. *Ligation above and below*, with excision or destruction of the sac: This method, also practised by the ancients (Philagrius), remains a desirable operation.

C. *Excision* and end-to-end arterial suture is the ideal operation when it is feasible.

D. *Aneurysmorrhaphy* (Matas): (1) *Obliterative Aneurysmorrhaphy.*—The

circulation is controlled, and the sac is incised and emptied without being isolated from surrounding tissues. Vascular openings into the sac are closed by suture, the sac obliterated by intrasaccular suture, and the overlying tissues

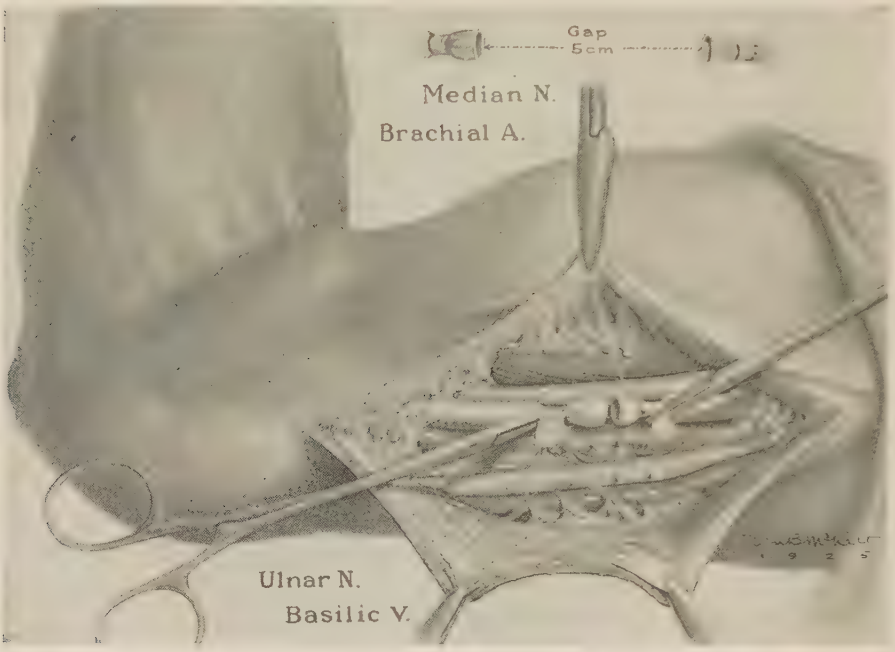


Fig. 259.—End-to-end arteriorrhaphy of the brachial artery: The aneurysm has been excised. Apposition of the divided ends is obtained by flexing the elbow and by gentle traction upon the vessel. Hemostasis by tapes wrapped around the artery and held by hemostatic forceps.

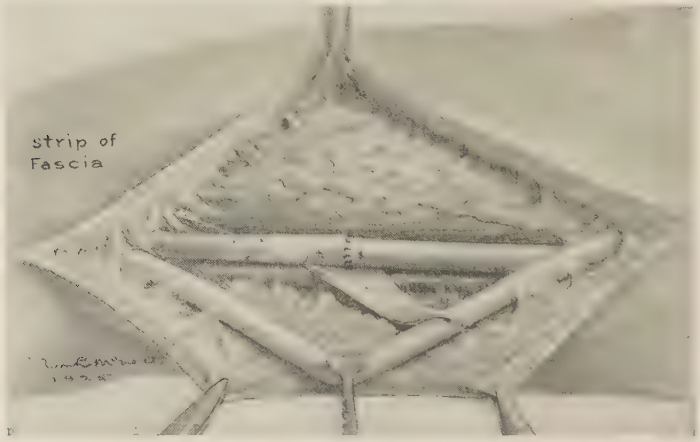


Fig. 260.—Arteriorrhaphy by end-to-end suture with interrupted sutures of fine black silk: Line of union being reinforced by suturing a narrow strip of fascia about it.

united. The operation has the merit of simplicity and of not damaging the anastomotic circulation adjacent to the sac. (2) *Reconstructive Aneurysmorrhaphy.*—The sac is opened and cleared of clot, and the arterial lumen is recon-

structed by suturing the walls from within over a rubber tube temporarily introduced as a form between the two main openings of the sac. The redundancy of the sac is then obliterated by enfolding intrasaccular sutures, as with the obliterative operation. These operations are practical, simple, and efficient, especially the obliterative aneurysmorrhaphy.

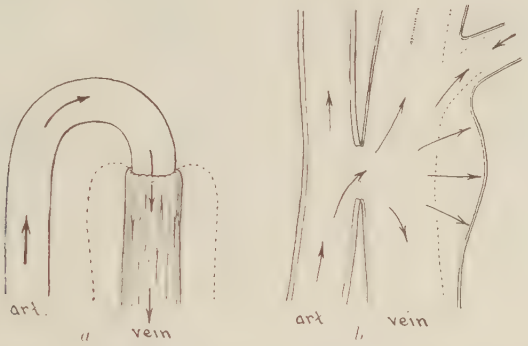


Fig. 261.—*a*, Showing collapse of vein and accelerated venous circulation from anastomosis of proximal ends of a large artery and vein due to the increased velocity in the vein. *b*, Showing dilatation of vein and retardation of venous flow from a side-to-side anastomosis.

III. Special Operations.—*Thoracic Aorta:* Rest, limitation of diet, bleeding, and antisyphilitic treatment should be used.

Operative decompression of the sac (Babcock, 1925) by an end-to-end suture of the central ends of the divided common carotid and deep jugular has given a satisfactory result in a single case.

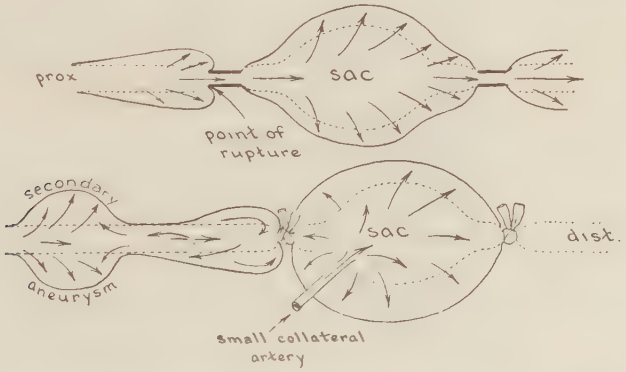


Fig. 262.—Proximal dilatation of artery and increased pressure within an aneurysm after proximal and distal banding or ligation.

Abdominal Aorta: Ligation or banding of the abdominal aorta, while permitting a sufficient collateral circulation, especially if done below the renal arteries, has with one exception been followed by death from hemorrhage, the result of pressure necrosis of the aortic wall at the point of constriction. The patient of Keen and DaCosta lived over forty days, although the ligature was proximal to the renal arteries.

Traumatic aneurysms involve, in order of frequency: The carotid, subclavian, axillary, brachial, femoral, and popliteal arteries. Occlusion of both artery and vein is less frequently followed by gangrene than is the occlusion of the artery alone (Makins).

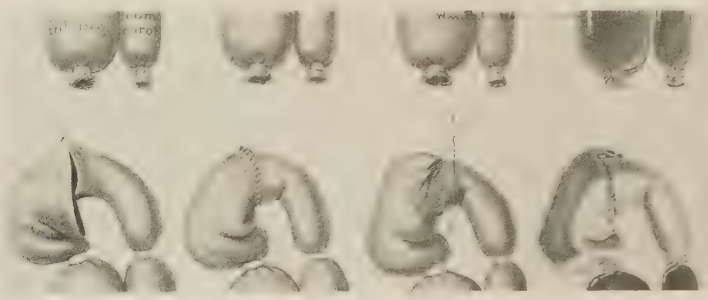


Fig. 263.—Babcock's operation for aneurysm of the thoracic aorta by proximal end-to-end anastomosis between the common carotid artery and the internal jugular vein to reduce the intrasaccular pressure.

Arterial False Aneurysm.—*Treatment:* (1) Suture or ligation of the opening in the artery. Obliteration of the sac. (2) Ligation of the artery above and below sac, with excision or obliteration of the sac.

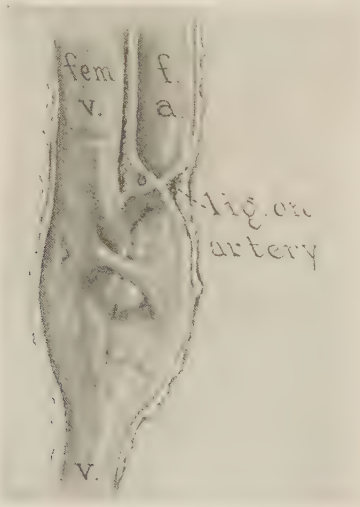


Fig. 264.—Wrong method of treating an arteriovenous communication between the femoral artery and vein the result of a gunshot injury by proximal ligation of the artery. Through arterial anastomoses below the ligation the veins became distended with arterial blood and the leg and foot became swollen, pulsated, and gangrene threatened.

Arteriovenous Aneurysm.—*Treatment:* (1) Ligation of artery and vein proximal and distal to the aneurysm. (2) Excision of the sac between ligatures. (3) Excision of the sac and end-to-end suture of artery and vein. Proximal ligation of artery alone may be followed by aneurysmal varix and gangrene, and should never be used.

In **aneurysmal varix** the opening may be closed through: (1) An incision in the vein, and suture (Matas). (2) Ligation of the connecting channel. (3)

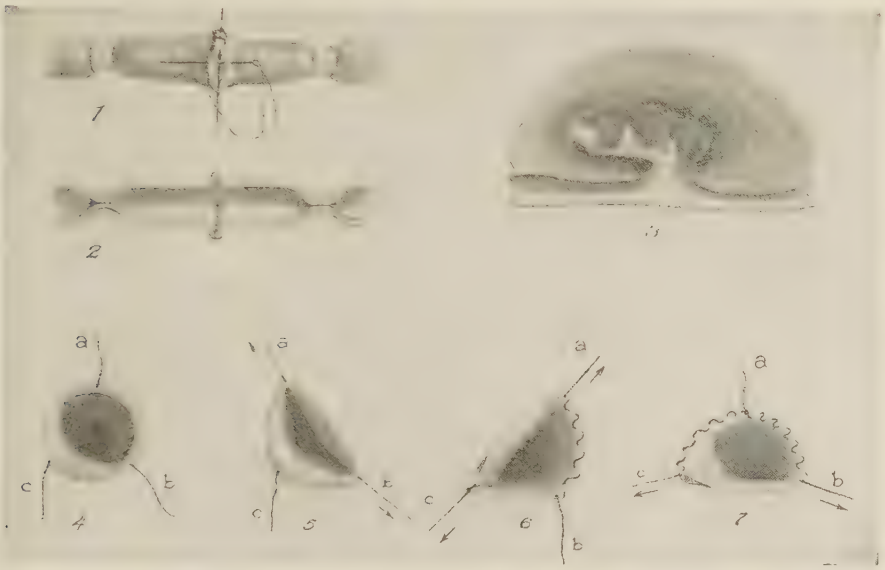


Fig. 265.—Technic of arterial suture: The artery is cut sharply across with the least possible traumatism, the adventitia pulled over the end and resected by fine sharp scissors, the arterial ends united at equidistant points by three traction sutures as shown in 4, 5, and 6, and a continuous everting suture of very fine black silk introduced by a No. 12 bead-threading needle, as shown in 1; 3 shows in section the laminated clot lining a traumatic aneurysm.

Separation of artery and vein, and closure of both openings by proximal and distal ligation of both arteries and veins. Proximal ligation of the artery alone is harmful.

DISEASES OF VEINS

Veins are subject to traumatic injury, thrombosis, inflammation (phlebitis), and to dilatation or varicosity.

Thrombosis of veins follows injury, infection, or inflammation. It is very common in phlebitis. The thrombus may: (1) Become organized, and permanently obstruct a vein; (2) be absorbed; (3) be followed by suppuration, with local abscess or pyemia; (4) form an embolus, or (5) become calcified, forming a *phlebolith* or vein-stone.

Phlebitis (inflammation of the wall of a vein) follows injury or infection. In the veins of the lower leg it is common during the puerperal period (*phlegmasia alba dolens*). It occurs after 2 per cent. of all abdominal operations, particularly operations upon the pelvic organs, and is not uncommon after typhoid and other exanthematous fevers.

Pathology.—An exfoliation of endothelial cells and roughening of the intima occurs, followed by the formation of thrombus, an arrest of circulation, secondary peripheral venous distention from the obstruction, with marked lymphatic engorgement forming the large white leg. With infection there is fever, rigor, marked pain, and tenderness. The center of the thrombus liquefies into pus,

the wall of the vein is perforated, and a secondary abscess forms in the adjacent soft tissues, which tends to point and discharge upon the skin surface.

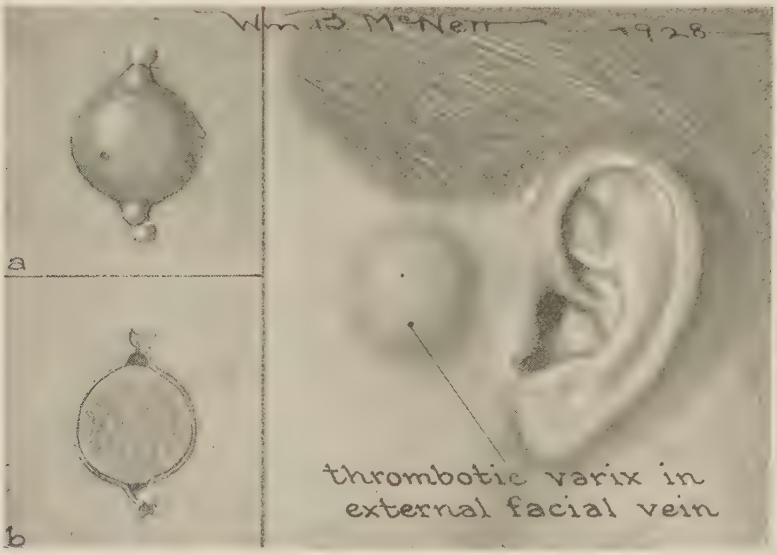


Fig. 266.—Laminated thrombus in varix of external facial vein.

Varieties.—1. *Saphenous phlebitis* (*milk-leg, phlegmasia alba dolens*) chiefly involves the great saphenous vein.

Fig. 267.—Phlebolith in cutaneous vein of leg following injury.

2. *Thrombotic external hemorrhoids:* Painful, firm, rounded, bluish masses occurring at the margin of the anus, due to thrombosis in the external hemorrhoidal plexus.

3. *Pylephlebitis:* Suppurative inflammation in the portal vein with multiple abscesses of the liver; results from a septic appendicitis or other infection in the pelvis or abdomen.

4. *Sinus phlebitis*, often septic in type, involves the sinuses of the dura.

Phlebitis may be: (a) *Exudative;* (b) *suppurative;* (c) *localized;* (d) *diffuse.*

Symptoms.—There is acute pain, with tender cord-like swelling along the course of the vein; associated with edema, swelling, and enlargement of the tributary veins, and followed, if the process is septic, by the formation of an acute abscess with redness of the skin and pointing.

Diagnosis is made by finding a tender cord-like mass in the course of a vein, with secondary passive congestion and lymphedema. A progressive increase of pulse-rate without fever suggests an aseptic phlebitis (*Mahler's symptom*). Recurrent chills after an abdominal operation suggests septic pylephlebitis or other blood-stream infection or toxemia.

Prognosis.—Saphenous or femoral phlebitis is fatal in about 2 per cent. of the cases, from secondary pulmonary embolism, pyemia, or other septic complication. The prognosis of thrombotic hemorrhoids is favorable. Pylephlebitis is almost invariably fatal, and the mortality of sinus thrombosis is about 60 per cent.

Treatment.—*Prophylaxis:* Avoidance of traumatism to the abdominal wall during abdominal operations, especially to the veins in the rectus muscle. Avoidance of prolonged immobility in bed. Gentle massage, cardiac tonics, the early use of the back-rest, or movement from the patient's bed are desirable. With the onset of thrombosis the patient should remain quietly in bed, with the affected part well elevated, and evaporating lotions, such as boric alcohol, aluminum acetate solution, or dilute lead-water, applied. A simple clean-cut incision should be made into the abscess as soon as suppuration is evident. Under no condition should massage, curettage, manipulation, excision, or irrigation be permitted, as dislodgment of clot and secondary fatal embolism have frequently followed such interference. Even the ligation of the vein is dangerous in purulent phlebitis. A thrombotic hemorrhoid should be incised, however, and the clot gently expressed or excised. In phlebitis of the leg the patient should usually remain in bed for six to eight weeks, an elastic supporting bandage from the toes to the thigh being applied before the leg is lowered. Often permanent edema and enlargement of the leg follow with a sense of weight and heaviness, for which the patient should daily wear an elastic bandage or stocking.

Sinus Phlebitis.—The sinus should be exposed, incised, and drained, without attempt to dislodge the clot. The ligation of the internal jugular vein, frequently advised, is unnecessary and adds to the danger.

Chronic phlebitis somewhat resembles arteriosclerosis. There is thickening, varicosity, and, at times, calcareous changes in the walls of the vein. It follows the infectious fevers, as typhoid fever, smallpox, yellow fever, and occurs with syphilis, gout, alcoholism, rheumatism, and blood-stream infections.

Treatment is usually that of the underlying condition, and of varicose veins.

Phlebitis migrans is characterized by multiple fusiform swellings along the veins, especially of arm and about the elbow. The masses are firm, moderately

tender, a few centimeters in length, without thrombosis or marked edema, and may spread along the vessel. The cause is unknown except occasionally; the process seems to be syphilitic.

Varicose veins (*varix*, *phlebectasia*) is a permanent dilatation of one or more veins, usually with elongation, tortuosity, and thickening of the walls. The great and small saphenous veins of the leg, the hemorrhoidal veins (*hemorrhoids*), the spermatic veins (*varicocele*), and those of the pampiniform plexus (*varicocele of the round ligament*) are most frequently affected.

Etiology.—1. Congenital or acquired weakness of the walls of the veins, especially from phlebitis.

2. Absence or incompetency of the valves of the vein.

3. Obstruction to the venous return, as by garters, bands; abdominal distention, as from pregnancy, intra-abdominal tumors, or effusions.

Fig. 268.—Varicose veins of the right leg.

4. Cardiac and pulmonary disease, and especially cirrhosis of the liver.

5. Gravity and muscular strain, as in occupations requiring much standing, and contraction of the muscles of the leg.

6. Compensatory or collateral dilatation of veins.

7. Abnormal communication with an artery as in aneurysmal or arterial varix.

Varicosities are more common (a) in women, (b) after pregnancy, and (c) after middle life. There is hypertrophy of the media, a chronic phlebitis with fibroconnective tissue deposit and, at times, atheromatous change. In the local pouchings the media is atrophied, the adventitia much thickened. The valves are damaged and become incompetent, permitting back flow. In the leg the process is much more marked in the superficial cutaneous and subcutaneous rather than in the deep veins of the muscles.

Symptoms.—In the leg, tortuous dilatation is most common along the course of the great saphenous vein, and over the popliteal space. There is secondary retardation of the venous circulation, with capillary dilatation, congestion and stasis, rupture of capillaries, and interference with nutrition. The skin shows congestion, edema, pigmentation eczema, ulceration (*varicose ulcers*). The muscles atrophy, with weakening of ligaments (*pes planus*). The patient, especially after standing, complains of dull pain, aching, and tiredness of muscles.

Varicosities are more marked in the left than the right leg, although the condition is usually bilateral. The incompetency of the valves is shown by *Trendelenburg's test*, in which the patient lies down and elevates the leg to empty the veins. Pressure is now applied to the upper part of the great saphenous vein, and the patient is made to stand. Normally the veins will fill gradually from below. If the vein suddenly fills from above when the pressure is removed, the valves are incompetent. If the varices distend quickly on standing,

despite the pressure, the valves of the deep anastomotic branches are incompetent (Chevrier). Valvular incompetency is also shown by an impulse felt over the varices when the patient stands and coughs, and by an impulse transmitted distally through the valves on tapping over a vein at a higher level.

Complications include rupture of the dilated vein through the overlying thin skin, with profuse hemorrhage; phlebitis and local infection and, rather rarely, embolism.

Treatment.—1. *Palliative*, consists in graduated support and compression, by the constant wearing of an elastic woven bandage or an elastic stocking, while the patient is upon his feet; with

Fig. 269.—Test for valvular incompetence in the great saphenous vein. The impulse from bent finger percussion over the vein in the thigh is transmitted to the veins below the knee if the valves are incompetent.

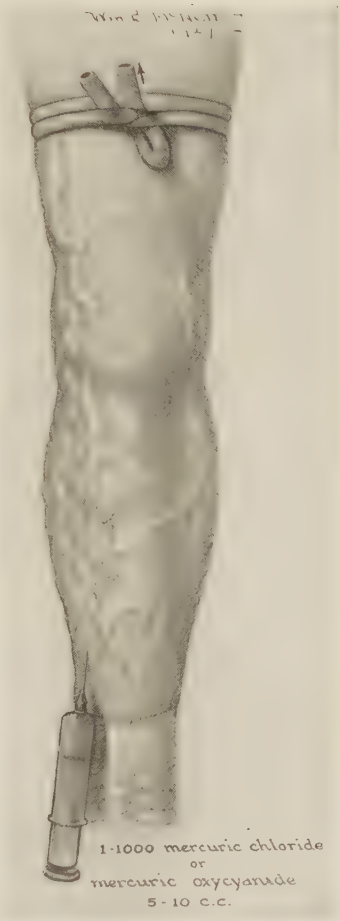


Fig. 270.—Technic for the injection of sclerosing solution in the treatment of varicose veins of the leg. A distal roller bandage and a proximal rubber constrictor with sufficient tension to prevent the venous return have been applied. Five to 10 c.c. of a $\frac{1}{10}$ per cent. solution of mercuric chlorid are slowly injected into the enlarged blood-vessels.

elevation of the leg when the patient is sitting; the prevention of prolonged standing positions or muscular tension while at work; daily cold salt pediluvia, and the treatment of eczematous and ulcerated areas.

2. *Operative treatment* consists in obliterating, ligating, or excising the affected vein. *Obliterative* or *sclerosing injections* to produce thrombosis and organization within the wall of the vein are valuable. Two to 10 c.c. of a 1 : 1000 solution of

mercuric chlorid (Hempel, 1924) or mercury oxycyanid are injected into the veins in the areas of greatest varicosity, the general circulation being protected during the injection and for five minutes afterward by a light tourniquet. Great care is taken that none of the solution enters the subcutaneous tissues, the needle-point and syringe being gently washed out with blood from the vein before the needle is withdrawn. A pressure pad and supporting bandage is then applied to the entire leg. The veins in the area of the injection become firm and thrombotic and, after several months, the vein is transformed into a fibrous cord. The injections are repeated at intervals of two or more weeks, until the larger varicosities are obliterated. Support and daily baths without friction or massage are continued until obliteration is complete. Usually the patient continues at work. A number of other substances—including a 20 to 40 per cent. pure sodium salicylate (Sicard, 1918), 3 to 5 per cent. quinin and urea hydrochlorid, and alcohol—have also been used, but probably are inferior to the mercurial injections.

Dalater first injects 2 c.c. of a 20 per cent. solution of sodium salicylate; reinjecting, after the reaction has subsided, 2 c.c. of a 30 per cent. and then 4 c.c. of a 40 per cent. solution; if this fails, Genevrier's solution (1917)—quinin hydrochlorid, 0.45; urethane, 0.23; and distilled water, 3—is used first in doses of $\frac{1}{2}$ to 1 c.c., later increased to 3 or 4 c.c. Genevrier's solution, used without tourniquet, is commended by Raymond Petit.

The injection should be avoided in patients with phlebitis, marked plethora, hypertension, or cardiorenal disease.

Trendelenburg's operation consists in the ligation of the great saphenous vein below the saphenous opening, best with an excision of a short section of vein.

Fig. 271.—Babcock's vein extractor with cupped acorn tips. Jointed type.

While two-thirds of the patients are improved, the varicosities continue in over one-half, due to the free collateral circulation.

Babcock's Venectomy.—A pliable probe, 26 inches long, with a small acorn tip at one end and a large acorn tip at the other, is introduced through a small incision into either end of the section of vein to be removed. The smaller acorn tip is pushed through the vein as far as it will go. Near the point where it has been entered by the instrument the vein is divided between ligatures, one of which firmly encircles the vein and the shaft of the instrument. The small acorn tip is now located under the skin, exposed through a short incision, and by traction, with a series of short, sharp jerks, from 15 to 65 cm. of vein are withdrawn, firmly pleated against the larger cupped tip of the instrument. The collateral branches tear off several centimeters from the main trunk, but cause little subcutaneous bleeding. Any additional enlarged veins are likewise removed, the small incisions are sutured, and a firm supporting bandage applied from the toes to the thigh.

In the after-treatment the patient remains in bed for seven to ten days, and a supporting bandage is continued for at least six weeks.

Schede's operation consists of a circular incision (*circumcision*) of the skin and subcutaneous tissues to the muscular sheaths at the junction of the middle and

upper third of the leg. The divided veins are tied, and the wound sutured. As an undesirable paraplegia or circulatory deficiency occasionally follows from division of the sensory nerves and all the superficial veins, the operation has been modified.

Fig. 272.—Position for removal of varicose veins.

Fig. 273.—Babcock's venectomy. The vein extractor is introduced into the great saphenous vein through a short incision at *a* and carried through the vein to the lowest possible level (*b*). The vein is divided between ligatures at *a*, the lower ligature encircling the shaft of the instrument. The instrument is exposed over the lower and smaller bulbous end at *b*, and withdrawn with short quick jerks, bringing away the vein pleated against the upper bulb of the instrument as shown in the insert.

Powell uses an interrupted circumcision. To make the division more complete *Friedel* employs a long spiral incision, encircling the leg a number of times

from the foot to the knee. The skin and subcutaneous tissues are divided, with division and ligation of all veins encountered.

Excision by Dissection.—Where the veins are very tortuous, the turning back of flaps of skin and the careful excision of the veins by dissection may be necessary. Unfortunately, the vitality of the skin is poor, and secondary extensive necrosis and sloughing may follow.

For *hemorrhage* from a varicose vein, the patient should immediately lie down and elevate the leg; this instantly arrests the bleeding. Further hemorrhage may be prevented by a pad and a firm bandage, applied from the toes to a point well above the opening.

Chronic eczematous areas and *varicose ulcers* usually improve rapidly after the veins are occluded or resected. Eczematous areas also yield to cleanliness, elevation, support by a well-fitting bandage, and local, mild, moist antiseptic dressings of boric acid, boric alcohol, aluminum acetate or black wash, or of bismuth paste or ointment. Unna's gelatin dressing is of value.

Ulcers should be carefully cleansed, stimulated by painting with tincture of iodin once or twice weekly, and covered by a piece of Lister's green protective, oiled silk, cello silk, or gutta-percha tissue, cut to the exact size of the ulcer. Over this, six layers of gauze wet with boric solution or a 2 per cent solution of aluminum acetate are applied, held by a supporting roller bandage running from the base of the toes to the knee. To prevent slipping the bandage should be evenly applied to the leg, as a descending figure-of-8, without reverses.

Choice of Operation.—The injection treatment is simple, relatively safe, and most generally applicable, although the possibility of secondary embolism must not be forgotten. With a descending reflux only, Trendelenburg's ligation is valuable. It should not be used where there is also an ascending reflux or a compensatory varicosity, as excision of the varix, venectomy, or saphenectomy is then necessary. All operations depend upon the fact that the deep veins lying in the muscles are better supported and usually have competent valves. Obviously, with the very rare insufficiency or obstruction of the deep muscular veins, the circulation in the superficial veins should not be interrupted.

Operative measures are usually ineffective for multiple fine cutaneous varicosities (broken veins).

Venesection (*phlebotomy, bleeding*) is a method of removing blood from the body, used at times for high blood-pressure, distention of the right heart, plethora, toxemia, and auto-intoxication. *Exsanguination-transfusion* consists of a phlebotomy followed by transfusion from a suitable donor.

Operation.—The median basilic vein overlying the brachial artery is usually selected, a bandage or rubber tube tightened above the elbow sufficiently to interrupt the venous return without arterial obstruction. While the patient makes a hard fist, the vein is incised by a small knife or lancet which quickly nicks the vein from the side, cutting away from the underlying artery. The blood is caught in a suitable receptacle, the flow being increased as desired by squeezing the fist. The patient, as a rule, should be in a sitting position.

A second method is to introduce a large hollow needle (caliber 14 to 15) into the vein, the blood escaping spontaneously or under gentle aspiration. The patient should be recumbent and the flow slow if it is desired to extract a large quantity of blood without syncope.

CHAPTER XX

THE LYMPHATICS

The Lymphatic System.—The lymphatics convey fluids from the tissues and serous cavities, and chyle from the alimentary tract to the circulating blood.

The *lymphatic system* consists of: 1. *Lymph-spaces* and *lymph-vessels* (a) in the tissues, (b) about blood-vessels (perivascular lymphatics), and (c) in serous membranes.

2. Lacteals for the chyle.

3. Lymph-nodes or lymph-glands which filter, detoxicate, and sterilize the lymph.

4. The thoracic ducts and receptaculum chyli, which carry the collected lymph and chyle to the subclavian veins. The lymph-vessels have thin endothelium-lined walls and many valves. The subcutaneous lymph-vessels have little communication through the deep fascia with the deeper lymphatics.

The *lymph reaches the blood:* (1) Chiefly through a large single or a double right thoracic duct, which joins the right subclavian vein near the root of the deep jugular. (2) The smaller left thoracic duct entering the left subclavian. (3) Variable accessory ducts.

Traumatic Injury.—With the division of the smaller lymph-vessels, a clear, colorless, coagulable lymph escapes. Normally the open lymph-spaces are soon occluded by coagulated lymph- and blood-clot, and the wound secretions are drained away by an ample collateral lymph circulation. If there is lymphatic obstruction or insufficient lymph drainage, a subcutaneous division of lymphatics is followed by *lymph accumulation*, *lymphedema*, or *lymph-cyst*, to be treated by elevation of the part, support, elastic pressure, aspiration, evacuation, or drainage.

With an open wound a continued escape of clear, watery lymph (*lymphorrhagia*) or a *lymph-fistula* may ensue. As a rule the discharge is temporary, ceasing under elevation, support, and pressure, or after cauterization of the wound by nitrate of silver or other agent.

Thoracic Duct.—With an open thoracic duct the chyle escapes synchronously with the respirations.

The injury occurs: 1. In operations upon the posterior triangle of the left side of the neck. The escape of milky chyle into the wound is noticed during the operation or, more often, later when the tissues become distended by chyle or a discharge of chyle (*chylorrhea*) occurs from the wound. Two, three, or four liters of chyle may be discharged daily, and the patient show dehydration and starvation, with thirst, emaciation, and weakness, which is fatal in 5 per cent. of the patients. Injury of the right thoracic duct is not serious.

If possible, the divided duct should be occluded by suture or ligation at the time of operation. In many cases the flow is spontaneously arrested as the wound

heals, but if persistent and free despite compression, packing, and cauterization by nitrate of silver, the wound should be opened and an attempt made to close the opening by ligature or suture.

2. In crushing wounds of the trunk the thoracic or abdominal portions of the duct may be lacerated or divided, with secondary *chylothorax*, *chylomediastinum*, or *chylous ascites*. The treatment is that of the associated injuries, with aspiration or paracentesis for the removal of the chyle. If the other injuries are not mortal, a spontaneous repair of the damaged duct usually occurs.

Lymphatic obstruction and **lymph-stasis** involves either the lymph-spaces, lymph-glands, or thoracic duct.

Etiology.—1. Congenital defect.

2. Pressure on the lymph-vessels by effusion, new growths, fibrous scars, tight bandages, and the like.

3. Obstruction of lymphatics by animal parasites (*filaria*), or through permeation by cancer-cells.

4. Occlusion through fibrosis or inflammation, as from the action of radium or Roentgen rays, lymphangitis, and perilymphangitis. After recurrent attacks of erysipelas a chronic edema may remain.

5. Obstruction or removal of lymphatics by operation or traumatic injury, as in the radical operation for cancer of the breast.

6. Venous obstruction, lymph-stasis, or lymph obstruction often is associated with phlebitis, thrombophlebitis, and varicose veins.

Symptoms.—The part becomes swollen, edematous, cold (*lymphedema*), and, if chronic, a perilymphatic fibrosis occurs, with solid edema which does not pit on pressure. The skin becomes thick, coarse, rough, and at times pigmented, and is thrown into coarse folds. The lymph-vessels are dilated or varicose (*lymph-varix*, *lymphangiectasis*), and become telangiectatic, cavernous, or cystic. There is reduced resistance to infection, and repeated attacks of erysipelas may occur with, at times, secondary obliteration of the lymphatics.

Special Varieties.—*Chylothorax* (*Chylous Ascites*): The accumulation of milky chylous fluid in the pleural or peritoneal cavity follows obstruction of the thoracic duct by carcinoma or other malignant tumor, by animal parasites, as filaria or bilharzia, or injury or division of the duct. The treatment is paracentesis for the removal of the fluid and the management of the underlying condition.

Lymphedema of the arm usually follows radical amputation of the mammary gland for cancer, and especially involves the posterior and mesial portions of the arm and forearm. If the edema is continuous and increases, it indicates the progressive obstruction of lymphatic channels by the growth of the neoplasm. The arm is greatly swollen, heavy and painful, and the finer movements of the hand are prevented. Secondary hyperplasia of connective tissue may result, with the development of elephantiasis.

Treatment.—(1) Elevation, bandaging. (2) *Handley's lymphangioplasty:* Heavy tubular silk is carried from the chest, by long probes introduced subcutaneously, to the wrist and hand to drain the subcutaneous cellular tissue around the areas of lymphatic obstruction. In certain cases the pain is so great that blocking of the brachial plexus by the injection of alcohol or amputation of the

arm is to be considered. It is to be remembered that these patients have a progressive ineradicable carcinoma, with a very limited expectation of life.

Filariasis (*filarial lymphangiectasis*) is due to the *Filaria sanguinis hominis* (*Microfilaria bancrofti*) carried by the intermediate host, a mosquito (*Culex fatigans, Stegomyia pseudoscutelleris*). The larvæ enter the body by a mosquito bite, or through the intact skin from polluted water. The adult filaria live in retroperitoneal tissues, and discharge embryos into the lymphatics, which later enter the blood. The lymphatic inflammation is often due to the dead worms, and usually occurs between the ages of twenty and forty years. Streptococcic or pyogenic infection is often associated.

The lymphatics are obstructed, dilated, thickened and tortuous, and contain clear or turbid lymph. The lymph-nodes are enlarged, and there are associated round-cell and eosinophil infiltration, formation of giant-cells, and diffuse fibrosis. The obstruction may involve: (1) The inguinal lymphatics with the formation of a large doughy, compressible swelling; (2) the tissues of the scrotum (*lymph-scrotum*), with enormous overgrowth, so that the scrotum may hang to the knees and weigh 50 or more pounds; (3) the lymphatics of the cord with the formation of *lymph varicocele;* (4) the skin and subcutaneous tissues of the foot, leg, and thigh (*elephantiasis*), with enormous hyperplasia of the skin and subcutaneous tissues.

Fig. 274.—Elephantiasis of the left leg—Barbadoes leg—due to obstruction of the lymphatics by filaria (Dr. Benjamin M. Harding).

In *lymphadenovarix* the lymph-nodes become much enlarged from the pressure of dilated lymph-vessels, which may slowly fill as the patient stands upright.

In *filariasis*, recurrent and periodic febrile attacks occur, with local pain, tenderness, and increased swelling due to the local lymphangitis.

Treatment includes: (1) Prophylaxis against infection; (2) the destruction of filaria; (3) the reduction in size or removal of redundant involved tissues. A plastic operation or skin-grafting may be needed to cover the defect left.

Elephantiasis arabum (*filarial elephantiasis*) involves the lower extremities, scrotum or, less often, the upper extremity, labia, mammæ, face, or scalp. Chyluria and lymphuria are often associated. The skin is dense, firm, hard, and roughened; the deeper tissues very thick, edematous, fibrous, and blubbery.

Prognosis.—Filarial elephantiasis is marked by periodic febrile attacks, with tenderness and increase in size of the involved part. Rarely spontaneous subsidence follows a pyogenic infection.

Treatment.—After a period of rest in bed, with elevation of the affected part and preparation of the skin, an operation for the establishment of lymph

drainage through the deep fascia is performed (*Kondoleon operation*), with or without resection of as much of the hyperplastic skin and subcutaneous tissues as is feasible. Amputation is seldom desirable.

False elephantiasis may be congenital or idiopathic; usually it is a sequel to partial or complete obstruction of the inguinal lymph-nodes. The enlargement is found chiefly in middle-aged obese patients, from repeated attacks of lymphangitis, phlebitis, or thrombophlebitis, usually with great thickening of the skin and subcutaneous tissues of the leg and ankle. The skin is thick, coarse, dry, infiltrated and rough, with a tendency to eczema and ulceration. The subcutaneous tissues are thick, edematous, and hyperplastic. The tissues beneath the deep fascia are relatively uninvolved. A persistent hereditary form of lymphedema of the legs occurs which terminates abruptly at the knee-joint or groin.

Treatment.—(1) Local cleanliness and the wearing of a supporting elastic bandage or stocking. Thyroid extract and massage. (2) Kondoleon operation (1912) aims to establish lymph drainage from the obstructed superficial to the unobstructed deep lymphatics beneath the deep fascia. Spiral incisions, free openings or windows, are, therefore, made through the deep fascia, usually with the resection of wedge-shaped portions of the redundant skin and subcutaneous tissue. The larger the amount of aponeurosis removed, the better. Sistrunk removes a large section of skin, subcutaneous tissue, and aponeurosis after treating the part by rest in bed with elevation, and bandaging for ten days to several weeks, a few moments being devoted to walking daily. Long curved incisions are made from the crest of the ilium to a point below the lateral malleolus, the subcutaneous fat and the aponeurosis freely divided, and the large ellipse of skin, subcutaneous fat, and aponeurosis excised. The wound is closed by interrupted silkworm-gut sutures without drainage. The carrying of strips of fascia from an attached end into the medulla of femur (Lanz, 1911) is unnecessary. Handley's lymphangioplasty (1908), with the subcutaneous insertion of cords of tubular silk, is of limited value.

Acute lymphangitis (*inflammation of the peripheral lymph-vessels*) occurs in pyogenic infections, chiefly from the staphylococcus and streptococcus. Red, tender, wavy lines run from the point of infection to the first tributary lymph-nodes, and perhaps to the second. From an infection of the finger the red lines run to the epitrochlear and cubital lymph-nodes at the elbow, and then, perhaps, to those in the axilla. From the toe or foot, the popliteal nodes and then the vertical or subinguinal nodes are affected; from the genitalia, pelvis, buttocks, and lower abdominal wall, the oblique or superficial inguinal glands.

Perilymphangitis and *perilymphadenitis*, with some thickening and edema or a spreading cellulitis and abscess formation, may be present. The red wavy lines are associated with burning pain, tenderness over the tributary lymph-nodes, edema, or pitting of the adjacent skin. After repeated attacks of lymphangitis, as from recurrent erysipelas, a permanent redness and thickening of the skin and subcutaneous tissues may remain.

Treatment.—Rest, elevation, evaporating lotions, or the application of an ointment of oxid of mercury, iodin, or ichthyol. Abscesses should be incised and drained.

Acute lymphadenitis (*acute inflammation of lymph-nodes or lymph-glands*) is secondary to infection in the area drained. In acute pyogenic lymphadenitis the lymph-glands become acutely swollen, tender, and, at times, matted together from periadenitis. Redness, edema, and swelling of the overlying skin, and an abscess frequently form. The condition is very common: (1) In the *neck*, in the submaxillary triangle from infection of the mouth, tonsils, or pharynx; in

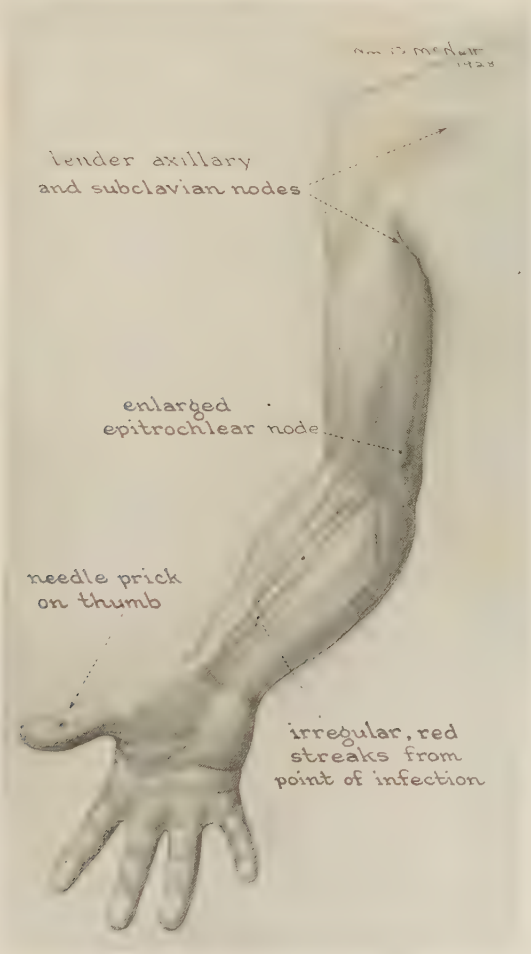


Fig. 275.—Streptococcic lymphangitis and lymphadenitis in a physician. Inoculation by a needle prick in operating for an appendiceal peritonitis. Initial symptoms within four hours, repeated incisions and manipulations, death on the fifth day. Absolute rest in bed, with avoidance of manipulation, operation, anesthetic, is indicated during the early period of streptococcic lymphangitis.

the posterior triangle from pediculosis, furuncle, carbuncle, or infected wounds of the scalp. (2) In the *upper extremity, mammary region*, and *thoracic wall*, in the supratrochlear, cubital, deltoideopectoral, and axillary glands from infections of the hand, forearm, arm, mammary gland and thoracic wall, and axilla. (3) In the *groin*, in the oblique set of glands lying parallel to Poupart's

ligament, from infections of the genital organs, abdominal wall and pelvis, and perineum or buttocks; in the vertical set of glands, from infections of the foot, leg, thigh, and external genitals.

Treatment is to relieve the primary infection by sterilization, evacuation, and drainage. Repeated irritation of the primary lesion, as by manipulation, curetage, or the application of strong antiseptics and caustics, should be avoided. Rest, with fomentations or mercurial ointment over the inflamed nodes, and incision and drainage when fluctuation indicates that suppuration has occurred, should be used.

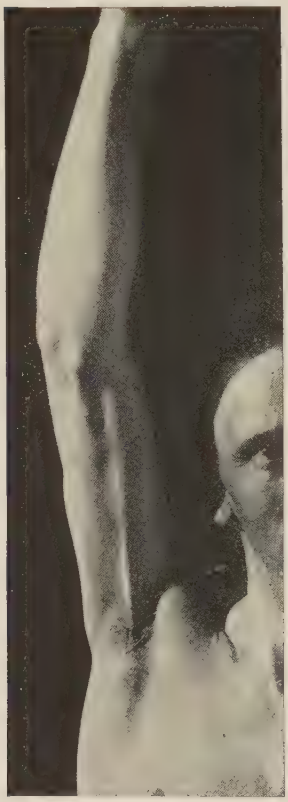


Fig. 276.—Tuberculous pipe-stem lymphangitis associated with tuberculous primary lesion on the forearm and satellite bubo in axilla. Tuberculous glands are subject to caseation and cold abscess formation. (Stokes.)

Chronic lymphadenitis may be simple, tuberculous, or syphilitic. *Tuberculous lymphadenitis* is very common in children and young adults.

Tubercle bacilli entering the body usually first invade tributary lymph-nodes and lymphadenoid tissue. From the mouth and pharynx, the tonsils, and adenoids the infection spreads to the submaxillary, carotid, parotid, mastoid, and supraclavicular nodes, the mediastinal and mesenteric lymph-nodes, occasionally to the subclavicular, axillary, and inguinal nodes.

First Stage.—The gland rapidly becomes large and tense, with a deposit of tubercles.

Second Stage.—Areas of caseation develop. The gland breaks down and liquefies, more particularly in children; or becomes fibrous, adherent, and indurated in adults. At first the glands are discrete, firm, smooth, non-adherent, after which they become fused, nodular, showing areas of varying resistance.

Third Stage.—Characterized by *suppuration* and *sinus formation.* The sinuses are chronic, persistent, leaving puckered scars with a tendency to keloid formation and telangiectasis.

From a proliferative periadenitis the glands become fused together, with secondary suppuration and sinuses, leaving a puckered keloid or vascular scar. There is little pain or tenderness.

Cervical tuberculous lymphadenitis frequently follows infection of the nasopharynx—the parotid, submaxillary, and deep cervical glands being chiefly affected, the axillary and deltoideopectoral more rarely.

Tuberculous lymphangitis is characterized by nodular thickening, the formation, at times, of perilymphangitic nodules, with chronic secondary abscesses, ulcers, and lymphadenitis. The extensive hyperplastic form has been termed *lupus elephantiasis. Syphilitic lymphangitis* is especially associated with the initial lesion, and the lymph-vessels form indurated cords in the edematous tissue of the penis, labia, or lip. The chancre may not be evident.

Treatment.—(1) Removal of sources of infection, as diseased tonsils and adenoids, eradication of dental, alveolar, or nasal infection. (2) Stimulation of the

general resistance by sunshine, fresh air, rest and feeding, and the injection of tuberculin. (3) Stimulation of local absorption by sunlight, ultraviolet light, or Roentgen-ray exposure; and by application of unguentum hydrargyri ammoniatum containing 1 per cent. of guaiacol. (4) The softening and liquefaction of glands may be hastened by injecting dilute tuberculin into their centers. (5) After liquefaction has occurred with the formation of a cold abscess, aspiration or evacuation of the abscess through a small incision. The discharge is facilitated by cerate dressings (guaiacol, ½ part; compound resin cerate, 10 parts). (6) Enucleation of diseased glands. This is not often required. (7) Chronic ulcers and sinuses may be treated by ultraviolet light or roentgenization. The application of tincture of iodin, zinc chlorid, or phenol—followed by alcohol or tincture of iodin, after which the cavity is filled with bismuth subnitrate or bismuth subiodid paste—is useful.

Residual calcareous and caseous masses may be curetted away, and secondary keloids or puckered scars treated by excision and plastic closure after all inflammatory process has subsided. The skin is mobilized and united to overcome the deformity.

Tuberculous disease of the glands of the groin is rare, and may follow tuberculosis of the toes, feet, or legs. *Tuberculous* mesenteric lymphadenitis (*tabes mesenterica*) is not uncommon in children.

Hodgkin's disease (Hodgkin, 1832), or **malignant lymphadenoma,** is a progressive, fatal disease, with lymphadenopathy and progressive anemia.

Etiology.—Male sex, early adult life.

Pathology.—A granuloma or lymphoma, with hyperplasia of lymphoid tissue and reticulum and great enlargement of discrete encapsulated lymph-nodes. *Distribution:* The enlargement usually first involves the cervical glands on one side, followed by the glands of axilla, groin, mediastinum, and abdomen, with hyperplasia of the lymphoid tissue of the digestive tract. At times a primary enlargement of internal glands occurs. The glands are round or oval, encapsulated, and non-adherent. The surface of section is gray and translucent without caseation. Microscopically they contain giant-cells with three or four nuclei (*lymphadenoma cells*), increased endothelial cells having large single nuclei, many eosinophils, and a great increase of fibroconnective tissue. The spleen usually shows moderate enlargement, and may contain grayish areas resembling in structure the diseased lymph-nodes (*hard-baked spleen*). Lymph-nodules may also be found in the liver, spleen, bone-marrow, and lymphoid tissues throughout the body. The blood shows a progressive secondary anemia, with reduced red cells, hemoglobin, and color index. A leukopenia with relative lymphocytosis is usual or, less frequently, a leukocytosis occurs, with increase of polynuclear cells in the terminal stages and moderate increase of eosinophils. The blood-changes are not diagnostic.

Symptoms.—A painless rapid enlargement of cervical glands, with later progressive pallor, anemia, and weakness. The glands are elastic, not craggy or matted, vary in size, and may by pressure cause: (1) Cough, dyspnea, dysphagia; (2) inequality in pupils and protrusion of eyes; (3) edema of the face; (4) paralysis of the recurrent nerve; (5) pain and edema of the arm; (6) signs of thoracic tumor with cough, dyspnea and cyanosis, edema, engorged

veins, pleural effusion; (7) abdominal pain, jaundice, ascites; (8) intracranial or spinal symptoms from involvement of the brain or spinal cord.

Types.—(1) *Localized Form:* A single group of glands enlarge. The disease remains quiescent for a considerable period, followed by a rapid general extension. (2) *Acute generalized* type. (3) *Pel-Ebstein Syndrome:* A period of gradually ascending pyrexia (to 103° or 104° F.) lasting ten to fourteen days is succeeded by an apyrexial period of the same duration. The nodes may increase in size during the fever. (4) *Typhoid Type:* Insidious onset, weakness, abdominal discomfort, malaise, high remittent temperature, is associated with enlarged spleen, leukopenia, and enlargement of retroperitoneal or mediastinal glands.

Prognosis.—Death usually occurs in from two to four years, or rarely after five to ten years. Usually there are periods of remission and improvement.

Fig. 277.—Hodgkin's disease with enlargement of the lymph-nodes of the neck, axilla, and groin.

Fig. 278.—Ileum with diffuse lymphomatosis, enlarged solitary follicles, and Peyer's patches. (Ewing, Neoplastic Diseases.)

Diagnosis.—*Tuberculous* lymphadenitis, the glands become irregularly nodular, contain cheesy foci, and later coalesce, caseate, and suppurate. *Syphilis*—the glandular enlargement is general, and moderate or slight. *Leukemia* is diagnosed by a leukocytosis above 40,000. Malignant tumors, sarcoma, and lymphosarcoma, tend to invade the skin with ulceration.

Treatment.—Operative removal of the glands may be performed for diagnosis and for the relief of pressure, but otherwise is of no advantage. The glands are easily extirpated. Arsenicals and radiation are of some value in retarding the evolution of the disease.

Lymphangioma may be cavernous, cystic, or telangiectatic. The mass is compressible, does not pulsate or become tense when the blood-pressure is raised, and contains lymph instead of blood. It resembles a lipoma or angioma.

Congenital lymphangiectasis with the formation of local tumors is not uncommon and involves the skin (*nevus lymphaticus*), lips (*macrocheilia*), the tongue (*macroglossia*), the neck or axilla or floor of the mouth (*cystic hygroma, lymphatic cyst, hydrocele of the neck*).

Macromelia, the congenital giant growth of a part, as the finger or toe, is usually in part lymphangiomatous.

In the neck the mass is situated beneath the deep fascia and projects in front of or behind the sternomastoid, may be of large size, largely encircles the neck, and interferes with respiration or deglutition. It often persists for years, then

Fig. 279.—Lymphosarcoma of cervical lymph-nodes. (Ewing, Neoplastic Diseases.)

undergoes spontaneous cicatrization, and disappears; or infection is followed by abscess formation, especially in the neck.

Treatment.—Radiation, injections of 5 per cent. quinin and urea, or boiling water, with care. Excision is often very difficult, particularly in children, and persistent lymphangorrhea, lymphorrhea, or serious infection may follow attempts at surgical excision in childhood.

Primary tumors of lymphatic glands are chiefly **lymphosarcoma,** a malignant lymphoma which may start in the neck, axilla, or mediastinum, grow rapidly, infiltrating the surrounding tissues and progressing to the skin, finally causing death by pressure, hemorrhage, cachexia, or secondary metastasis to lung and liver. It may be difficult to distinguish from Hodgkin's disease except by more rapid growth, unilateral character, and ulceration.

Treatment.—Excision, radiation. Recurrence, metastasis, and death is to be expected, but disappearance after radiation for two or three years is not unusual.

Lymphoblastoma.—*Malignant lymphoma*, a malignant tumor of the type of lymphadenoid tissue, is more frequent in males than females; more often occurring in early adult life than in childhood or old age.

Symptoms.—(1) Fever, malaise, weakness, cough, pain, itching. (2) Lymph-glandular enlargement, especially of the peripheral glands, the mediastinal glands (peritracheal group), and the abdominal glands. Jaundice follows invasion of the liver; hematuria, involvement of the kidney; altered reflexes and paralysis, the involvement of spinal cord or brain. The eyeball may be destroyed. The bones, especially the sternum, ribs, skull, and vertebræ, may be involved. Extensive irregular destruction, especially of cancellous bone, occurs with little or no osteogenesis, and often rapid extension to the surrounding soft tissues.

Treatment.—Radiation by the Roentgen ray with a short wave-length and a small dose (one-sixth to one-quarter the erythema dose over one field) every other day, until two-thirds of the erythema dose has been given. If the patient develops toxemia, the tumor begins to soften, or if leukopenia appears the radiation should be stopped. Unless the metabolism is elevated radiation is not advisable. The treatment may prolong life, but is not curative.

Secondary Tumors.—*Carcinoma* is chiefly diffused by the lymphatics, and is a common cause for enlargement of lymph-nodes in middle-aged adults. The glands become craggy, nodular, hard, fixed, and occasionally rupture, with the formation of foul, fungating ulcers. The left supraclavicular glands enlarge from carcinoma of the stomach. In *melanoma* of the skin, secondary lymphatic invasion is very common. *Rodent ulcer* does not metastasize to the lymphatics. *Secondary sarcoma* rarely involves the lymph-nodes, except with lymphosarcoma of the tonsil, thyroid, or testicle.

CHAPTER XXI

THE PERIPHERAL NERVES

Physiology.—A. Motor.—Efferent fibers leave the spinal cord with the anterior nerve-roots, and carry motor impulses to the muscles, and sympathetic impulses to blood-vessels, muscles, and other parts. Division of the motor fibers leads to a flaccid palsy of the lower neuron type. Division of the sympathetic fibers leads to vasodilatation and special effects in various regions of the body.

B. Sensory.—Afferent fibers from the periphery reach the spinal cord through the posterior roots, and convey the following forms of sensibility:

1. *Pain Sensation.*—Tested by the ability to recognize the prick of a pin. The *protopathic sense* (Head) includes recognition of painful cutaneous stimuli, of extremes of heat and cold, and painful sensations associated with the cutaneous hairs.

2. *Tactile Sense.*—The ability to recognize light touch, as produced by a camel's-hair brush or a wisp of cotton. The *epicritic sense* (Head) also includes the highly specialized tactile sensation, the ability to differentiate points 2 cm. apart, and the finer grades of temperature, between 72° and 104° F., described as cool to warm.

3. *Trophic Influence.*—After interruption of the nerves supplying a part, the muscles waste, contractures follow, and changes occur in the joints. The weight of the limb may cause elongation of ligaments and spontaneous dislocation. The skin becomes thin and glossy, the hair falls out, and eczematous eruptions or pressure-sores may develop; the nails become incurved and thickened (*turtle-shell nails*), and the skin is usually dry, pale, and cold. Without the protective sense of pain the part may be burned or injured by abrasion or pressure without the patient's knowledge. That the condition is due more to lack of use than to a pure interruption of trophic influences is shown by the disappearance of most of the trophic lesions when the part is protected, routinely bathed, and exercised by massage and passive movement. Severe trophic lesions, therefore, indicate neglect in treatment.

4. *Deep Sensibility.*—This includes recognition of: (a) The *sense of pressure* upon the part (*pressure sense*); (b) *joint sensation*, or the position of a joint on passive movement; or (c) *kinesthetic sense*, active muscle sensation, the knowledge that active contraction of the muscles is occurring. The fibers supplying deep sensation run with the motor nerves, and tend to leave them at a relatively high level to pass into muscles, tendons, and joints, so that, after division of a nerve, *deep sensation* may be retained in the part that is paralyzed, while *cutaneous sensibility* is lost.

5. *Sympathetic Sensation.*—The sympathetic fibers which, as the white rami, leave the spinal cord with the anterior nerve-roots between the second thoracic and third lumbar segments, supply the blood-vessels of the entire body,

produce vasoconstriction, dilation of the pupils, sweating, stimulation of the heart, inhibition of peristalsis, and may also supply plastic tone to the skeletal muscles. After leaving the paravertebral ganglia the sympathetic fibers have an independent course, usually along the larger blood-vessels, so that the division of a mixed nerve may produce no sympathetic effect.

Fig. 280.—Illustrating the normal elasticity and independent blood-supply of peripheral nerves. The intrinsic blood-vessels where nerves pass around joints are tortuous, permitting elongation when the joint is flexed. Ulnar nerve behind medial condyle showing normal tortuous vessels.

Nerve Injuries.—A peripheral nerve may be contused or bruised, compressed, stretched, lacerated, or divided. Contusion of a mixed nerve produces paresthesia or anesthesia, with pins-and-needles sensation, numbness, heaviness and muscular contractions, weakness, or paralysis. The symptoms are usually transient, as in striking the so-called "funny-bone" (the ulnar nerve).

Causalgia is the intense burning pain or other form of severe paresthesia following injury to a peripheral nerve by compression, laceration, or inflammation.

The **stretching** or **compression** of a nerve leads to partial or complete interruption. It may be due to faulty position, tumor, aneurysm, abscess or inflammatory mass, pressure from a fracture, dislocation, growth of callus, cervical rib, swelling, edema of the nerve or surrounding tissues in bony canals, or other inflammatory process. If the pressure has merely been temporary, and not destructive, the paralysis and anesthesia are transient, clearing up within a few minutes or hours. If the traction or pressure has been marked or prolonged, weeks or even months of treatment may be required for recovery, or the disability may be permanent.

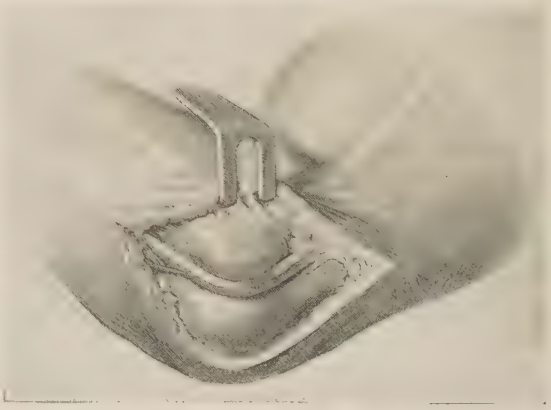


Fig. 281.—The ulnar nerve on flexion of elbow showing how the vessels of the sheath lose tortuosity from the normal stretching of the nerve.

Laceration or Division of Nerves.—Peripheral nerves are elastic, strong and tough, and have an independent blood-supply. They often escape when the adjacent tissues are severely lacerated or divided. The strain required to break various nerves, given by Trombetta, is as follows: Sciatic, 183 pounds; tibial, 114 pounds; anterior crural, 83 pounds; median, 83 pounds;

ulnar and radial, 59 pounds; brachial plexus in the neck, 48 to 63 pounds, and brachial plexus in the axilla, 35 to 81 pounds. A selected third of a nerve may be divided without evident anesthesia or paralysis.

Pathology of Nerve Division.—After a nerve is divided, and beginning four days after the division, Wallerian degeneration involves the peripheral portion of the nerve and the proximal portion as far back as the first node of Ranvier. The medullary substance breaks into droplets, and is absorbed; the axis-cylinders swell, fragment, disintegrate, and disappear in one month; the nuclei of the neurilemma proliferate, and the nerve-trunk becomes fibrotic and is invaded by leukocytes. Axis-cylinders grow from the proximal end and, with fibroblasts, invade the adjacent organized blood-clot. If there is not too great a separation between the nerve-ends, these unite and axis-cylinders gradually grow into the distal segment. The myelin-sheaths are re-formed, and regeneration toward the periphery proceeds at an average speed of 1 mm. a day, or about 1 inch a month.

Immediate suture of the divided ends does not prevent Wallerian degeneration, which in all cases precedes the regeneration by the progressive peripheral growth of axons from the divided proximal end. After more than a year has elapsed from the time of division, the union of a divided nerve end may not be followed by regeneration, the peripheral segments having become so fibrotic that the downward growth of axis-cylinders is no longer possible.

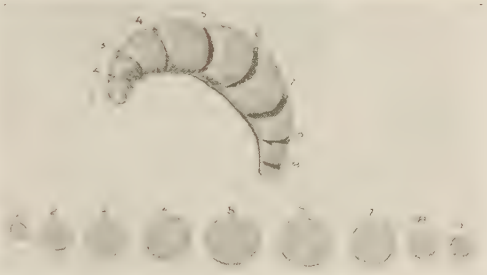


Fig. 282.—Resected fusiform traumatic neuroma in continuity, showing the absence of nerve bundles in the median portion.

Traumatic Neuroma.— If, after division, the distal portion is separated more than 2 or 3 cm. from the proximal end of the divided nerve, the outgrowth of axis-cylinders forms a convoluted and entangled mass of fibers and connective tissue, producing a bulbous nerve end or neuroma.

1. *Proximal Neuroma.*—The proximal fibroneuroma after an amputation is termed an *amputation neuroma*. It is frequently tender, painful, and the seat of severe causalgia.

2. *Neuroma in Continuity.*—After a nerve has been crushed, lacerated, or imperfectly united without division, a bulbous enlargement or fibroneuroma may develop in the course of the nerve. This may also be associated with severe causalgia.

3. *Distal Neuroma.*—The distal end of the nerve becomes fibrous and atrophic, or shows a smaller bulbous end.

After injury the nerve may become edematous and swollen, or infected and inflamed with neuritis.

Symptoms of nerve division or interruption include: 1. *Sensory interruption*, with loss of protopathic and epicritic sensibility in the areas supplied by the nerve-fibers below the point of division. With a root lesion the peripheral area of protopathic loss is much greater than that of epicritic. With a peripheral

lesion, the area of epicritic loss is greater than that of protopathic. There is a marked overlapping of the areas supplied by sensory nerves.

2. *Paralysis.*—The muscles supplied by the divided nerve-fibers show an immediate and complete loss of voluntary power. They atrophy, become fibrotic or fatty, and deformities occur from the unopposed action of the unparalyzed muscles.

3. *Electrical Reactions.*—In from three to five days the muscles no longer react to the faradic current. Excitability by the galvanic current, at first increased, is finally slowly lost. The *reaction of degeneration* which occurs includes loss of faradic excitability, but greater galvanic excitability with a sluggish contraction and a change in polarity, so that there is greater contraction at the anodal than at the cathodal closing. Later the muscles become degenerated and fibrotic, and all electrical excitability may be lost. The reaction of degeneration

Fig. 283.—Division of median and ulnar nerves near the wrist by gunshot injury. Loss of thenar and hypothenar eminences. Wasting of intrinsic muscles of hand.

indicates a complete interruption of impulses through the nerve. It is of limited prognostic value.

4. *Deep Sensation.*—Unless a high division of a nerve has occurred, deep sensibility may be retained, as the nerves supplying deep sensation run in muscles, tendons, and bones. Early tests for deep sensibility should be made, so that the later finding of it does not lead to error.

5. *Trophic Changes.*—(a) *Nerve Irritation, Partial Division,* or *Traumatic Neuritis:* The skin becomes thin, shiny, bluish red (*glossy skin*), or there may be vesicular (herpes) or pustular eruptions, ulcers, paronychia or whitlow, chilblains, hyperidrosis, brittleness, and loss of the hair. The nails become brittle, ridged, or lost from paronychia.

(b) *Complete division* is characterized by rough, scaly, and edematous skin; anhydrosis, atrophy of the sweat glands, atrophy and increased brittleness of bone, cessation of growth, brittleness and falling out of hair, and brittle thick

nails or exfoliation of the nails—conditions which may be prevented or improved by massage and passive movements.

Symptoms of Nerve Regeneration.—After complete interruption of a mixed nerve, regeneration is indicated by: 1. *Deep Pressure Tingling* (*D. P. T., Tinel's Sign*).—Light percussion over the nerve-trunk below the point of injury causes tingling in the area of distribution of the nerve. The point, at which tapping produces the tingling, gradually moves toward the periphery as regeneration occurs. This response indicates that there is some degree of regeneration, but it does not prove that motor or complete sensory return will follow.

2. *Protopathic sensation*, shown by the recognition of the prick of a pin, is the first to return and is associated with trophic improvement.

3. *Motor return* occurs earliest in the distribution of the muscular branches first given off below the point of injury. Muscular return is earlier and more complete than epicritic sensation.

4. *Epicritic sensation*, shown by recognition of the light touch of cotton or a camel's-hair brush, returns more slowly and less completely than any other. After division of a nerve with a complicated function, such as the ulnar nerve or anterior tibial, complete recovery of epicritic sense is not to be expected.

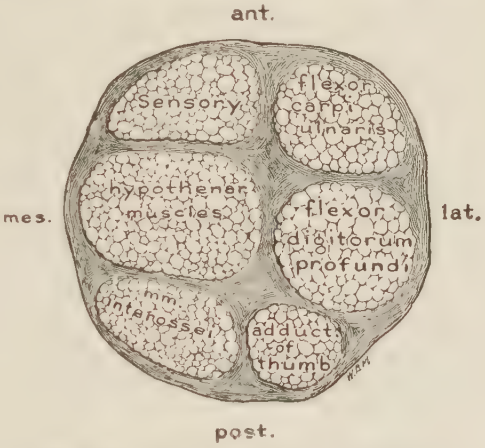


Fig. 284.—Arrangement of nerve bundles in the ulnar nerve just below the elbow (diagrammatic). By a knowledge of the nerve pattern an accurate diagnosis of a partial nerve injury may at times be made. In suturing a nerve the nerve ends should be so united that the proper bundles are apposed.

Diagnosis of Nerve Division.—*Partial division* of a mixed nerve is characterized by loss of epicritic sensation. There may be little protopathic loss and, indeed, one-third of certain mixed nerves may be divided without sensory loss. A typical reaction of degeneration is absent, loss of faradic excitability and brisk reaction to galvanism occurring, without polar reversal however.

Unilateral spinal-cord lesions give loss of movement, loss of the sense of position and tactile discrimination on the side of the lesion, and loss of sensibility to pain, heat or cold, and of tactile sensation and deep sensation of the corresponding segments opposite the lesion (*Brown-Séquard syndrome*).

Hysteria gives atypical symptoms not corresponding with the anatomy and physiology of innervation of the part. Frequently complete loss of all forms of sensation, with a circular upper margin, producing a *glove* or *stocking anesthesia*, is present. There may be an associated flaccid or spastic paralysis without change in the electrical reactions. *Ischemic paralysis* (*Volkmann's contracture*) is characterized by shortening of the flexor muscles without actual paralysis, with possible areas of sensory loss and trophic change.

Neuralgia is characterized by paroxysmal pain referred to the distribution

of a nerve, without obvious organic cause. The condition is often difficult to distinguish from inflammation or irritation of a nerve. It may be: (a) *Primary* or *idopathic;* (b) *secondary* or *sympathic*, in which case it may be toxic, as from gout, rheumatism, lead, malaria, influenza, alcohol, diabetes or typhoid, and a true neuritis; or (c) *from pressure*, as with a tumor or aneurysm.

Symptoms.—The pains are burning, shooting, cutting, lancinating, or like an electric shock, and last from a few seconds to several minutes. Between attacks there may be a dull ache or absence from pain. Hyperesthesia and tender spots are usually present, often at the point of emergence of the nerve from a bone. The condition is unilateral, limited to a single nerve or to a branch of a single nerve, but may spread and involve other branches or other nerves. The attack may be precipitated by movement, cold, a touch, or a draft of air upon the skin.

Varieties.—1. *Trigeminal neuralgia* (see page 727).

2. *Cervical occipital neuralgia* involves the posterior branches of the first to the fourth cervical nerves, and may be unilateral or bilateral. There is pain at the back of the head and neck, and especially along the greater occipital nerve, with hyperesthesia between the spine and mastoid and over the scalp.

3. *Brachial neuralgia* involves the branches of the brachial plexus, with pain in the shoulder, axilla, and along the ulnar side of the arm to the fingers. There are tender spots behind the elbow, over the ulnar nerve, in the axilla, and from the axillary (circumflex), along the posterior border of the deltoid.

4. *Intercostal Neuralgia.*—Involvement of the anterior branches of the second to the ninth dorsal nerves produces a constant ache, with paroxysms that are increased by respiratory movement. Tender areas, often with severe hyperesthesia, are found near the spine, the midaxilla, and the sternum, where the three sets of cutaneous branches are given off. *Herpes zoster* is quite frequently associated.

Mastodynia involves the nerves supplying the mammary glands (second to the sixth intercostal). It especially effects women, and arouses the fear of a malignant growth.

5. *Lumbar neuralgia* involves the lumbar plexus, with pain and tenderness referred to the iliac crest, the scrotum, labia majora, the testes, spermatic cord, or inguinal canal.

6. *Crural neuralgia* is referred to the area of distribution of the femoral (anterior crural) nerve at the front of the thigh, and may be associated with disease of the appendix, colon, or with sciatica.

7. *Coccygodynia* (*coccydynia, coccygalgia*) involves the coccygeal plexus, and especially effects neurotic and hysterical women. It often is very obstinate, and the pain may be increased by sitting.

8. *Metatarsalgia* (*Morton's painful affection of the foot*) is characterized by pain at the fourth metatarsophalangeal articulation, which may extend up the leg. It is usually unilateral, occurring chiefly in women. During a paroxysm the patient may be compelled to remove the shoe and support the foot. It is ascribed to compression of the digital nerves between the heads of the fourth and fifth metatarsal bones, and is associated with flattening of the anterior arch of the foot.

Painful heel may be secondary to gonorrhea, and accompanies plantar neuralgia with bony spur, or the tender toes of typhoid.

Sciatica is neuralgia of the sciatic nerve.

Etiology.—(1) Severe or unusual exertion with free perspiration, followed by chilling of the surface. (2) Unusual movement involving the region of the pelvis. (3) Expression of a focal infection of a distant part, such as teeth, tonsils, appendix, gall-bladder; or a contiguous infection, as from a pelvic appendicitis, gout, rheumatism, diabetes, gonorrhea, syphilis, or pressure of pelvic tumors. It is rare in youth, belonging rather to middle age.

Pathology.—A distinct neuritis may be present, or pathologic change absent.

Symptoms.—Sciatica begins gradually or abruptly with pain along the course of the sciatic nerve, and soreness and tenderness at the greater sciatic notch, the midthigh, popliteal space, and foot. The pain is increased by exposure, exertion, pressure, and traction. There is a painful point where the nerve crosses near the head of the femur. *Lasègue's Sign:* With the patient lying upon the

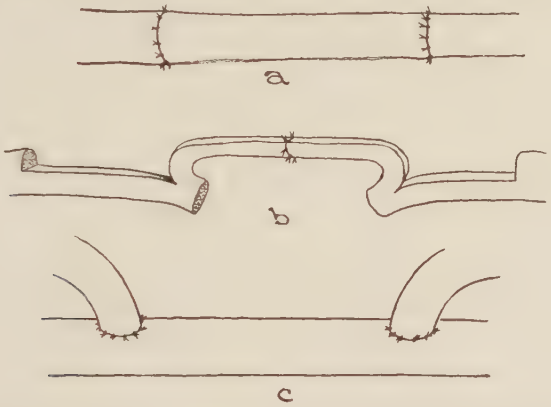


Fig. 285.—Methods of nerve anastomosis to be avoided: *a*, Substitution suture; the nerve ends are united by lateral implantation to an adjacent healthy nerve. *b*, Union of divided nerve by flap formation. *c*, Nerve graft.

back, if the thigh is flexed with the knee extended severe pain is produced in the region of the hip, popliteal space, or along the nerve-trunk. The muscles supplied by the sciatic nerve may undergo atrophy.

Differential Diagnosis.—Care should be taken to differentiate tumors of the pelvis and spine; sacro-iliac tuberculosis, which is most common in adolescence; hip-joint disease, in which there is pain on rotating the thigh or pressure upon the trochanter; lumbago, tabes, and intermittent claudication, in which the pain occurs after exertion and does not follow the distribution of the nerve. Lesions of the cauda equina are bilateral; the sphincters are affected and there are sensory changes. A bilateral sciatica suggests a general cause, such as diabetes, gonorrhea, or syphilis. In all cases a rectal or vaginal examination, a bimanual examination, a metabolic and roentgenologic examination, and a Wassermann test should be made.

Treatment.—(1) Remove possible toxic factors. (2) Treat any underlying constitutional conditions. (3) Rest in bed, elimination, local heat, counter-

irritation, violet-ray, radium treatment, and hydrotherapy. (4) Cinchophen, ½ to 3 gm. thrice daily with much water. (5) Injections into the nerve of: (a) 2 to 5 per cent. phenol; (b) 2 c.c. of 1 per cent. quinin and urea hydrochlorid (Hertzler); or into the sacral hiatus of: (a) 50 to 100 c.c. normal saline, or (b) 50 c.c. of 1 per cent. procain.

Acupuncture.—A needle, 10 cm. long, is introduced at a point one-third of the distance between the tuberosity of the ischium and the great trochanter, pushed forward and slightly upward and mesad, until the patient complains of paresthesia along the course of the sciatic. If bone is encountered, the point of the needle is withdrawn 2 cm. and the position of the needle changed until paresthesia is produced. The needle is then left in place for fifteen minutes, and then removed; or two to six needles are inserted along the course of the nerve for from fifteen to twenty minutes.

Nerve stretching (neurectasis) is of limited value, and is best done under an anesthetic. In "dry" stretching the thigh is flexed on the abdomen, and the leg strongly extended upon the thigh for five to fifteen minutes. Open stretching is performed by a 7-cm. vertical incision in the upper posterior femoral region, with medial displacement of the biceps. The nerve-trunk is isolated, and the patient's hips raised from the operating table by traction on the nerve. The wound is closed without drainage.

OPERATIONS UPON PERIPHERAL NERVES

The four important operations are: (1) *Exploration*, (2) *neurolysis*, (3) *hersage*, and (4) *neurorrhaphy*.

Nerve exploration is a most important step in any operation upon an injured nerve, for the needed treatment is determined by its findings. Failure to properly explore the nerve-trunk has been responsible not only for failures in operative treatment, but has produced serious errors in the conclusions and statistics of operators. The exploration must freely isolate the nerve in all its areas of possible injury, prove that it is the nerve sought, and especially that its component bundles are not subject to interruption or compression. The exposure should be free and, if there is any doubt as to the identity of the exposed cord, it should be traced to an unmistakable landmark. All points of possible compression or abnormal adhesions should be released, and the nerve-sheath, if thickened or abnormal in appearance, should be split freely in the long axis of the nerve. With a thin, non-adherent nerve-sheath, careful inspection and palpation is sufficient; but if the nerve is adherent, the sheath thickened, and evidence of the condition of the enclosed bundles obscured, the sheath should be freely opened and the nerve-bundles sufficiently exposed to prove their condition. This exploration may reveal lateral, central, or total areas of fibrosis that were not clearly evidenced before the nerve-sheath was opened. The fact that a cord has the diameter, contour, and position of a normal nerve-trunk does not prove that it is a normal nerve. Such exploration skilfully done is harmless.

Electrical Tests.—With a fine bipolar electrode and a weak induced current tests may be made upon the exposed or open nerve: To show the conductivity through a damaged area; to prove the distribution of a nerve; to work out the nerve pattern or the situation and function of the individual nerve bundles,

and to locate corresponding bundles above and below the injury as a guide to suture. Electrical tests upon the exposed nerve to determine sensory conduction are of limited value. With a patient unconscious and under an anesthetic, the guide to sensory interpretation is lost. With local anesthesia, contact of the anesthetic with the nerve may prevent conduction.

Motor tests made by applying a fine bipolar electrode to various parts of the exposed or open nerve-trunk, and carefully noting the muscular contractions produced, have limitations. The nerve may be conductive, but the muscles from advanced fibrosis and atrophy non-contractile. The nerve-fibers may be non-conductive from pressure within or without the sheath. The electrical current may radiate to adjacent nerve-fibers or muscles, producing contractions that lead to erroneous conclusions.

After division, electrical conductivity through a nerve is rapidly lost. After union of a divided nerve the reaction of degeneration persists, and the absence of electrical conduction continues after other clear evidences of regeneration are present. The electrical reactions lag behind other signs, indicating the regeneration. A nerve showing a fibrous block, or a macroscopic interruption of fibers, will rarely be found electroconductive. Careful inspection of an exposed injured nerve, therefore, gives more reliable evidence as to the degree of injury than do the electrical tests.

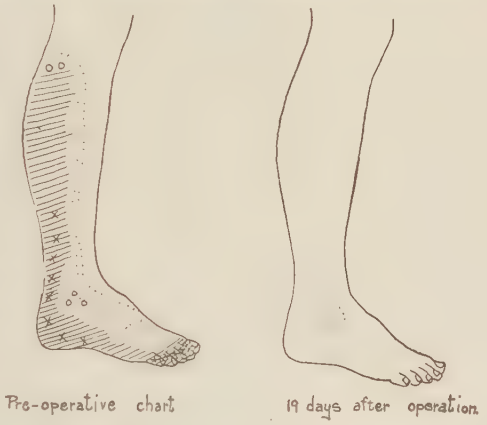


Fig. 286. Paradoxical almost immediate return of sensation after suture of a divided peroneal nerve. The anomalous return of sensation was due to liberation of the undivided but compressed superficial peroneal branch. From experiences like this the operator may erroneously conclude that regeneration after suture of a divided nerve is possibly within a few days or weeks. Dots indicate loss of tactile sensation; cross lines, pain sensation; crosses, the loss of muscle sense.

Neurolysis.—The liberation of a compressed or adherent nerve is the simplest operation for restoring conduction. The nerve may be strangulated in scar tissue, compressed by fibrosis, callus, bone fragment, tumor, a Lane plate, or other foreign body. The operation consists in first exposing the nerve above and below the point of injury, and then carefully freeing it through the area of compression, avoiding injury to the nerve-trunk or its important branches; after which the nerve is placed in a soft vascular bed, preferably a normal intermuscular plane, and the wound sutured. If the nerve has been compressed against a bone, a layer of muscle or other soft tissue is sutured between the bone and the nerve. The wrapping of the nerve with avascular tissue, fat, Cargile membrane, or other foreign substance is undesirable. It is usually wise to split the nerve-sheath, to relieve tension, and to make sure that the contained bundles are uninterrupted. Drainage of the wound is not required, and return of sensation and motion may be noted within a few days after the operation. Neurolysis may be useful even after neurorrhaphy to relieve compression from connective tissue.

Hersage (*combing*, or *the dissociation of the fibers of peripheral nerves*—Babcock, 1907) is employed when conduction is interrupted by conditions within the nerve-sheath not sufficiently severe to require excision of the diseased seg-

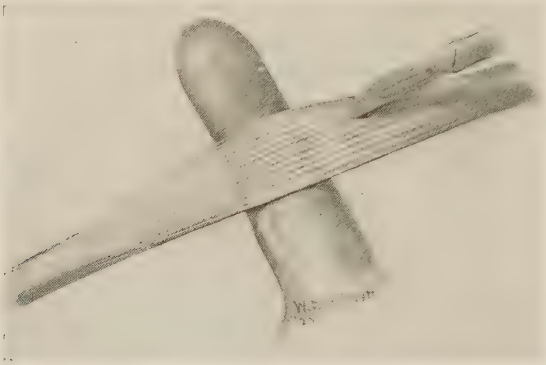


Fig. 287.—Hersage, a nerve-fiber dissociation. With a fine, very sharp knife the nerve trunk is converted in the area of fibrosis to a flat ribbon of separated fibers. If carefully done, the operation is often followed by an early improvement in sensation and motion which, however, is rarely complete.

ment with end-to-end suture. Thickening of the nerve-sheath, intraneural exudate, limited fibrosis, and certain partial neuromas in continuity are thus treated. The term is applied to a variety of operations, ranging from the splitting of the

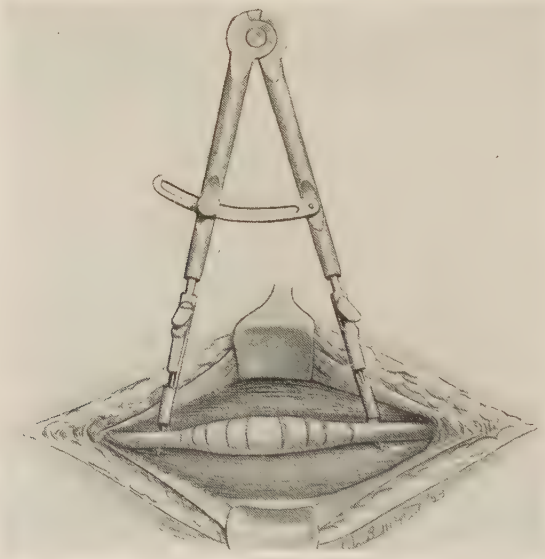


Fig. 288.—Technic of neurorrhaphy. The nerve with a fusiform neuroma in continuity has been freed from adjacent tissues, the nerve-trunks pinned by fine needles to the nerve clamp, and transverse incisions made with a razor blade to determine the extent of destruction of nerve-fibers.

sheath with one or two slight incisions in the nerve to a thorough dissociation of fibers throughout the area of disease, by which the rounded nerve is transformed into a ribbon of very fine, free fibers, in continuity with the nerve-trunk.

The operation permits the escape of exudate from within the nerve-sheath, reduces pressure upon individual nerve-fibers, frees axis-cylinders which have been rendered useless through entanglement in scar tissue, facilitates the formation of new or the restoration of old nerve-paths, and stimulates and favors desirable trophic changes in the nerve-trunk.

A free longitudinal incision of the nerve-sheath is made extending well beyond the limits of the lesion. The nerve-trunk is lifted upon the finger or a suitable blunt hook and held taut, and the nerve-fibers carefully separated, by a steady drawing or pushing movement, by means of a small sharp tenotome. Care is taken to divide as few nerve-fibers as possible, and to freely separate the nerve-bundles from each other. If cicatricial tissue is encountered in the nerve, the

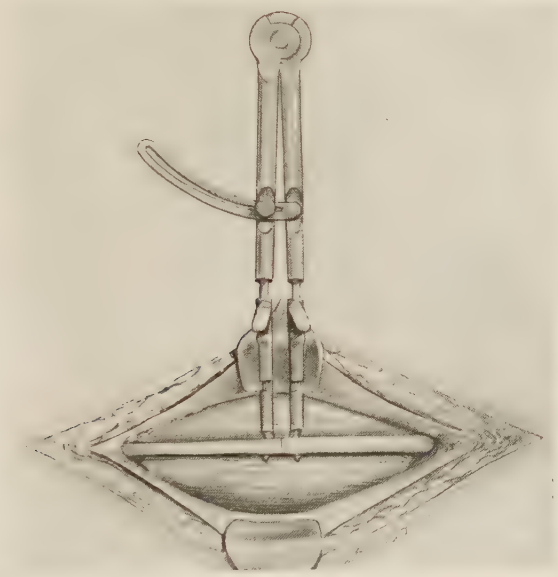


Fig. 289.—The neuroma having been excised, the ends of the divided nerve are apposed by the nerve clamp preparatory to suture. After suturing the anterior part of the sheath the clamp is rotated 180 degrees for suture of the posterior portion of the sheath.

separation of the fibers is prolonged along straight lines, dividing the scar tissue into multiple parallel threads. The knife should be sufficiently sharp to separate the nerve-fibers without unnecessary pulling, tearing, or bruising.

Usually, if the lesion is a partial one, this operation does not increase the previous anesthesia or paralysis, and a surprising restoration of function may appear a few days after the operation. If, however, the nerve lesion is extensive, complete return of function is rare and a partial or complete resection of the nerve with suture is to be preferred. The effect of hersage, however, may first be tried before resorting to resection and suture. After the operation the nerve is placed in a soft vascular bed as in a normal intermuscular plane.

Neurorrhaphy (*suture of a divided nerve*) should refer to but one method,

namely, an accurate end-to-end suture. *Suture à distance* with strands of silk or other material (with or without conducting tubes of Cargile membrane, fascia, hardened arterial wall, or other substances), substitution suture, nerve-flap formations, and lateral implantation are so ineffective or have such disadvantages as to be obsolete.

Technic.—A very free incision is made over the course of the affected nerve, which is exposed in healthy areas above and below the point of lesion. The nerve is carefully traced from the healthy area through the area of interruption, the ends of the nerve fixed in a nerve-holder, and sliced back by parallel transverse cuts, until the fibrous tissue has been removed and the nerve-bundles are shown. The line of section usually passes through three areas: First, through fibrous neuromatous scar, showing no macroscopic evidence of nerve-fibers; second, through an area of chronic neuritis, marked by a swollen nerve-trunk and fused hyaline or edematous nerve-bundles; third, normal appearing nerve, the nerve-bundles separating and tending to project from the surface on section, giving a brush-like end. The nerve ends should be resected into the second area or, if it is feasible to unite the nerve ends after the removal of the additional tissue, the section should be carried well into the third area. The nerve ends should be accurately matched, apposed, and united by very fine black-silk sutures passed through the sheath only. Sutures through the nerve-trunk produce fibrous areas, and should be avoided. Catgut is more irritating than silk, and should not be used.

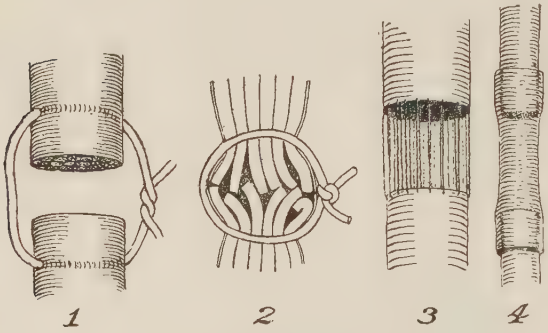


Fig. 290.—*Undesirable* methods of uniting divided nerves: 1, 2, A transfixion suture distorts the fibers and interposes a zone of inflammatory reaction and degeneration in the line of the advancing neuraxes. 3, *Suture à distance* is rarely effective and is useless in gaps over 3 cm. in length. 4, Tubulization, the nerve ends being introduced into a tube formed of a section of vein, of Cargile membrane, or other material. This introduces a foreign body for secondary absorption and interferes with the vascularization of the ends of the nerve, reducing the blood-supply to the regenerating fibers.

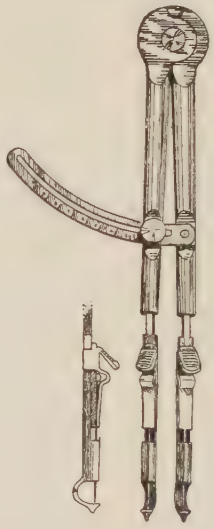


Fig. 291.—Babcock's nerve clamp for holding peripheral nerves during suture. The nerve ends are transfixed by a very fine needle or steel pins and are gradually brought together as the nerve is freed. The clamp greatly shortens the time for suture and prevents displacement and disorientation of the nerve ends.

Gaps in peripheral nerves may be closed by: 1. Making use of the

normal slack and elasticity of nerve-trunks. Gaps up to 3 cm., dependent upon the nerve-trunk liberated, may be overcome in this manner alone.

2. **Flexion and extension of adjacent joints** is of the greatest value. Acute flexion of the knee permits the closure of a gap of 8 cm. in the sciatic or popliteal nerves; of the wrist, 4 cm. in the median or ulnar nerve, and, of the elbow, up to 5 cm. in the radial or median nerve.

3. **Adduction or Rotation of Adjacent Joints.**—Adduction of the arm and elevation of the shoulder enables the closure of a gap of 7 cm. in the radial nerve

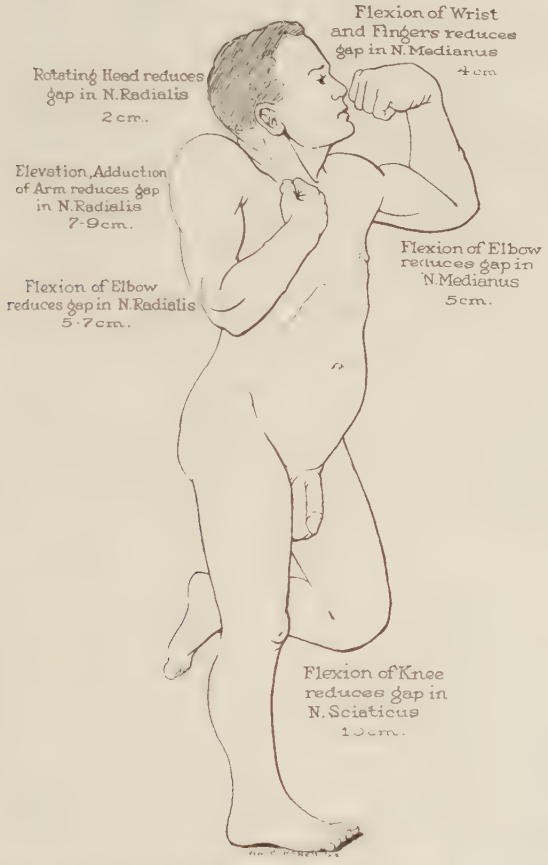

Flexion of Wrist and Fingers reduces gap in N. Medianus 4 cm
Rotating Head reduces gap in N. Radialis 2 cm.
Elevation, Adduction of Arm reduces gap in N. Radialis 7-9 cm.
Flexion of Elbow reduces gap in N. Medianus 5 cm.
Flexion of Elbow reduces gap in N. Radialis 5-7 cm.
Flexion of Knee reduces gap in N. Sciaticus 10 cm.

Fig. 292.—Positions used in overcoming gaps in peripheral nerves. The length of gap that may be thus overcome is indicated.

or other branch of the brachial plexus. Rotation of the head to the opposite side gives 1 or 2 cm. additional slack to the cords of the brachial plexus.

4. **Rerouting.**—A shorter and more direct path may be formed for certain nerves. By bringing the ulnar nerve from behind the inner condyle to the front of the elbow, and then flexing the elbow, the distance the nerve subtends may be shortened 7 cm. By rerouting the median nerve from the deep to a superficial position at the elbow, and acutely flexing the elbow, about 12 cm. slack is obtained. By unwinding the musculospiral nerve from the humerus, and re-

routing it (a procedure rarely indicated) to the front of the humerus, the distance traversed by the nerve is shortened 3 or 4 cm. Rerouting is a severe procedure,

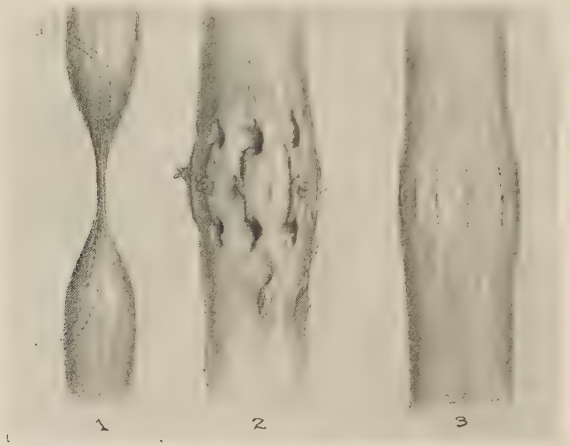


Fig. 293.—The reaction in peripheral nerve-trunks from suture material: 1, Sciatic nerve united by *suture à distance* with a large braided silk suture five months before. No reactionary degeneration of the nerve has been produced by this large non-absorbable suture which was introduced when the wound was débrided for gunshot injury in France. 2, Showing pockets of liquefaction and absorption in the median nerve from a neurorrhaphy with chromic catgut performed four months before. The wound was free from infection, and while no abscesses were present, the sutures have produced marked destruction of the nerve ends. 3, Fine black-silk sutures uniting the median nerve shown after five months. Absence of destructive action upon the nerve is evident. Catgut should not be used.

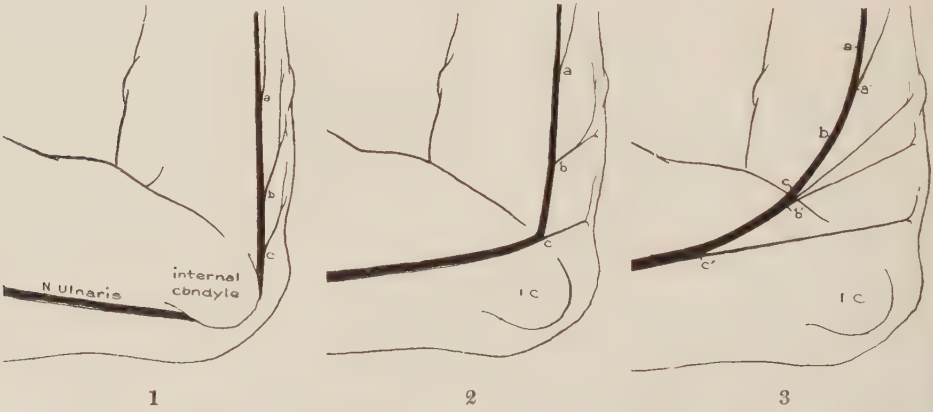


Fig. 294.—Rerouting the ulnar nerve to the front of the elbow. Illustrating the greater length of slack to be obtained by splitting the sheath of the nerve and stripping back the muscular branches. This enables the nerve to assume a more anterior position at the elbow. 1, Ulnar nerve at the elbow with muscle branches *a*, *b*, *c*. 2, Ulnar nerve dislocated in front of medial condyle; the transplantation is restricted by the binding effect of branches *b* and *c*. 3, The sheath of the ulnar nerve has been split, permitting the branches *b* and *c* to leave the nerve at a higher level and the nerve to be dislocated in front of the elbow, thus gaining several additional centimeters of slack. Without attention to such details, the operator, in attempting to close a large gap in a nerve, may be led to a useless and unnecessary nerve-graft.

and is not to be employed when simpler measures will suffice. It may be necessary to open the sheath, to strip back restraining branches so they emerge at a higher point on the parent trunk.

Fig. 295.—Retractor for peripheral nerves.

5. **Elongation of a nerve** by a two- or three-stage operation. At the first operation the nerve ends are brought as close together as possible, and are united under moderate tension by sewing the neuromas together or by *suture à distance*. The nerve-trunk is then progressively elongated by extending or otherwise moving adjacent joints. When the limit of elongation has been reached, the nerve is again exposed, the ends freed, the gap overcome, and neurorrhaphy performed. This operation, or the resection of long bones to enable gaps in nerve-trunks to be overcome, is rarely required.

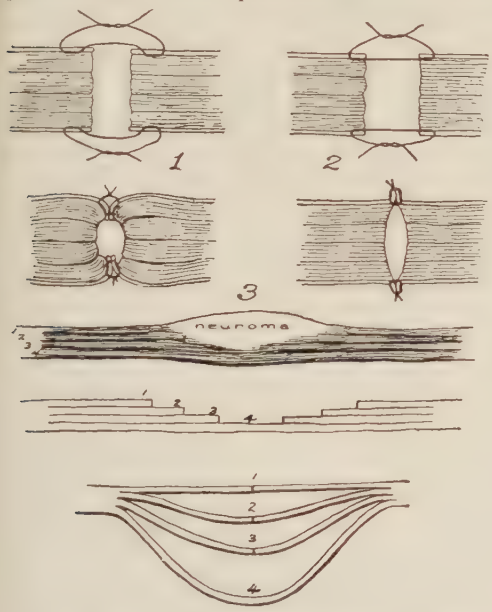


Fig. 296.—Methods of nerve suture: 1, Faulty method of suture of the nerve sheath producing inversion so that the sheath lies in the line of growing neuraxes; 2, proper method of suture of the sheath with fine silk, producing eversion. A 2 or 3 mm. separation of the nerve ends is desirable to facilitate orientation in the down-growth of neuraxes. 3, Neuroma in continuity showing step resection without complete division of the nerve. This method enables any residual function of the nerve to be conserved.

6. **Direct Implantation of Nerve into Muscle.**—A muscle, cut off from its source of nerve-supply, may be innervated by implanting a nerve into the muscular substance (Heineke). The nerve-trunk may be split into a number of separate bundles, which are embedded fan-fashion into the paralyzed muscle.

7. **Nerve-stretching** (*neurectasis*) is employed in neuralgia, neuritis, perforating ulcer of the foot, varicose ulcer of dystrophic type, angioneurotic conditions, muscular spasm, and spasmodic tic.

8. **Nerve-grafting.**—The gap in a nerve may be bridged by a section of nerve taken from another part of the patient's body or an amputated leg. If the transplanted section is smaller in diameter than the nerve to be grafted, several sections may be placed together, forming a cable (*cable graft*). For cable transplant a segment of the medial brachial (lesser internal) cutaneous, or the superficial branch of the radial in the arm, or the lateral femoral (external) cutaneous, or sural (short saphenous) nerve of the leg may be used. A down-growth of neuraxis usually takes place into the graft, but, before the lower end is reached, such a degree of fibrosis occurs that the further down-growth of axis-cylinders is prevented. A secondary operation, with resection and suture of the lower fibrotic end of the graft, may then be attempted.

Prognosis.—*Nerve-grafting* is rarely necessary, usually valueless, and should be avoided. It is employed, at times, where large gaps are present in nerves, but, as a rule, without success. Flaps of nerve, nerve inlays, substitution operations, where the ends of a divided nerve are grafted into the side of an adjacent nerve, and similar operations are useless and should be discarded.

It is a rule to which there are rare exceptions (Babcock) that if a gap in an important peripheral nerve cannot be overcome without grafting or resection of bone, then that part will be found to be so disorganized that a nerve suture will be useless and unnecessary. As a corollary, a graft or bone-resection to enable the suture of a nerve usually indicates that the operator has failed to use the full resources of his art.

The following table gives the approximate maximum gaps in peripheral nerves which may be overcome, permitting an end-to-end suture:

APPROXIMATE GAPS IN CENTIMETERS IN PERIPHERAL NERVES WHICH MAY BE CLOSED WITH END-TO-END SUTURE

Nerves.	By slack and elasticity.	By joint position.	By rerouting.	Total.
Brachial plexus	1½ cm.	3 + 7 cm.	....	11½ cm.
Radial in arm	3 "	7 + 5 "	....	15 "
Radial in forearm	1½ "	5 + 4 "	....	10½ "
Ulnar in arm	3 "	7 "	6 cm.	16 "
Ulnar in forearm	1½ "	5 "	6 "	12½ "
Median in arm	3 "	5 + 7 "	....	15 "
Median in forearm	1½ "	4 + 3 "	13½ "	22 "
Sciatic	3 "	3 + 8 "	....	14 "

After-treatment.—Preceding and following the suture of peripheral nerves paralyzed muscles should be kept relaxed by appropriate splints until sufficient voluntary power has returned; the nutrition of the part maintained by massage and passive movement, and the ankylosis or stretching of supporting structures about the joints prevented by movement and support.

After nerve suture great care should be taken not to disrupt the nerve ends by violent movements of adjacent joints. If an end-to-end suture has been possible by acute flexion of an adjacent joint, a safe rule is not to begin extension of the joint until ten days after the operation, and then to increase the extension 2 degrees a day on a measured arc until full extension is obtained. Excessive extension is prevented by splints, slings, or other restraining support. Thus, if it has been necessary to flex the elbow to an angle of 90 degrees to attain an end-to-end suture of the median nerve, the restraint should be so loosened by the tenth day as to permit movement to 92 degrees and, by the eleventh day, 94 degrees. Forty-five days later the elbow should be straight, or at 180 degrees. It is to be expected that regeneration will be somewhat slower when the nerve has to elongate as well as regenerate.

Causalgia.—Intense burning pain following injury to peripheral nerves may be due to adhesions, compression, a fibrous neuroma (terminal or in continuity), or a neuritis.

Treatment.—Neurolysis, hersage, or even resection and suture may be necessary. For neuritis, division of the sheath and a limited hersage is useful. The injection of alcohol or similar substance in a mixed nerve is illogical, except in an

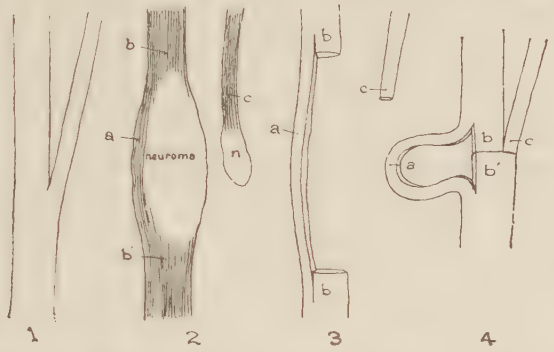


Fig. 297.—Illustrating method of suture for partial neuroma in continuity: 1, Nerve with branch before injury. 2, *a*, *b*, Nerve-trunk with neuroma in continuity. *c*, Separated branch with terminal neuroma, *n*. 3, Illustrating resection of neuromatous tissue. Branch showing at *c*. 4, Measuring-worm type of suture with union of branch, *c*, to the distal end of the nerve.

amputation stump, and will rarely be found necessary if the nerve is explored and the lesion corrected. In an amputation neuroma, a plastic operation to join the terminal fasciculi may also be done. With partial division or obstruction

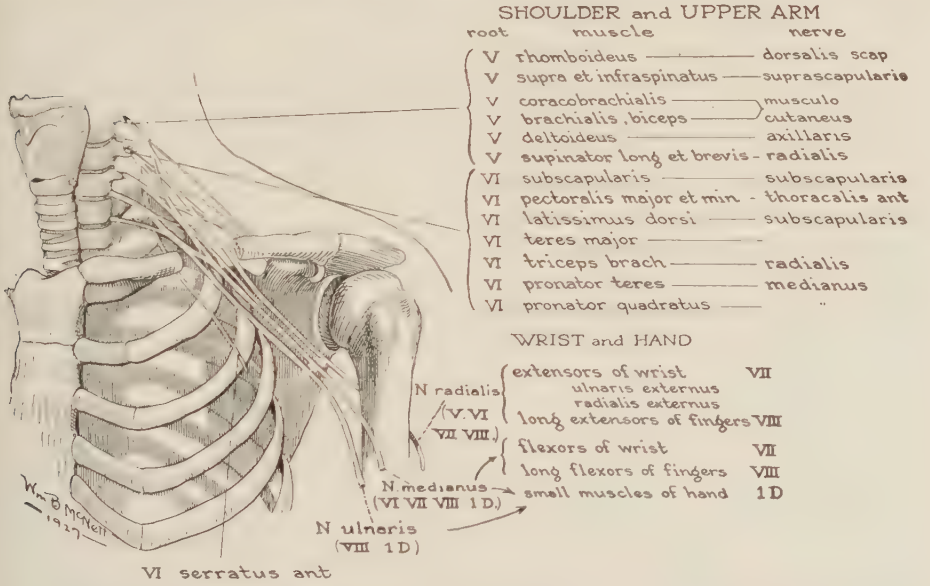


Fig. 298.—The brachial plexus, its origin and distribution. All of the root fibers are not given. Thus the brachioradialis (*supinator longus*) may receive fibers from the sixth cervical, the supinator (*supinator brevis*) from the sixth, seventh, and eighth cervical.

in a nerve, it is wise to split off the injured from the functioning fasciculi and do a partial or *measuring-worm suture.*

Regeneration.—The speed of regeneration (after nerve suture) from the point of division is about 1 mm. a day, or 1 inch a month. The down-growth of cer-

tain sensory neuraxes is more rapid. Deep pressure tingling (Tinel's sign), pins-and-needles sensation, when the skin over the nerve is tapped below the injury, precedes the return of pain, motor, and tactile sense and usually indicates that they will follow, at least in some degree. If no evidence of regeneration has occurred after twice the normal period of time allowed, the nerve should be re-explored by operation. For example, if the radial nerve has been sutured 100 mm. (4 inches) above the belly of the brachioradialis, faint voluntary contractions of this supinator should appear in four months or one hundred days. If, despite massage, and appropriate support to maintain relaxation of the paralyzed muscle, no voluntary contraction appears after eight months, the nerve should be re-explored, freed through the area of suture to remove sources of pressure, the sheath split through the zone of anastomosis, and any visible sutures removed. Reoperations may show pressure from a scar or callus, irritation from sutures, evidence that the nerve ends were not sufficiently resected, or actual separation of the nerve ends. The results of neurorrhaphy upon nerves with a simple function, as the radial or tibial, are much better than upon those of more complex function, such as the ulnar and common peroneal. In nerves of the latter type a return of perfect function is hardly to be expected.

LESIONS OF SPECIAL NERVES

Brachial Plexus.—Injuries of the brachial plexus may be *complete* or *partial*. Complete injury is exceptional. Partial injury includes the upper-arm and the lower-arm types.

1. **Complete Lesions.**—The arm is paralyzed, hangs by the side, and there is complete sensory and motor paralysis; a flaccid paralysis of the lower motor neuron type. The serratus anterior, the rhomboidei, and the levator scapulæ are not affected. Involvement of the branch of the first dorsal to the sympathetic system may cause myosis, narrowing of the palpebral fissure, and, possibly, slight enophthalmos.

In *supraclavicular rupture* of the entire plexus, resulting from direct or indirect violence, sensation is lost over the arm except on the medial side adjacent to the axilla, which is supplied by the intercostobrachial nerve. In *infraclavicular rupture*, which usually results from indirect violence or gunshot injury, there is complete loss of sensation.

2. **Partial Lesions.**—The medial cord of the plexus may be injured by a subcoracoid dislocation, with loss of function in the area supplied by the ulnar nerve, together with paralysis of the small muscles of the hand supplied by the medial head of the median. The lateral cord of the plexus may be injured in dislocation of the shoulder, with paralysis of the biceps, coracobrachialis, and all muscles supplied by the median except those in the hand. The posterior cord supplying the radial and axillary nerve is rarely injured. Injury of the *posterior root* of the fifth cervical produces postaxial anesthesia of the arm. The plexus may also be damaged by direct or indirect violence through blows, wounds, or falls on the neck, or attempts at reduction of dislocation of the shoulder. In fracture of the clavicle the displacement of fragments or overgrowth of callus may cause brachial palsy. Tumors or subclavian aneurysm may rarely cause pressure paralysis.

(a) *Upper radicular syndrome (Erb-Duchenne syndrome, brachial birth-palsy, obstetrical palsy)* results from injury of the fifth and sixth cervical nerves, causing the arm to be adducted, rotated inward, and to hang at the side.

There is loss of abduction (from paralysis of the deltoid), flexion of the elbow (the biceps, brachialis, and the brachioradialis), and supination of the hand. External rotation of the arm is lost, from the involved supra- and infra-spinati. The active subscapularis adducts the arm and rotates it inward. There is *little sensory loss.*

(b) *Middle radicular syndrome* is due to paralysis of the seventh cervical nerve with weakness or paralysis of the muscles supplied by the radial nerve, except the brachioradialis. The triceps and those extensors supplied also by the sixth cervical are weakened, but not completely paralyzed. The sensory loss is limited to a small area on the dorsum of the hand and adjacent forearm.

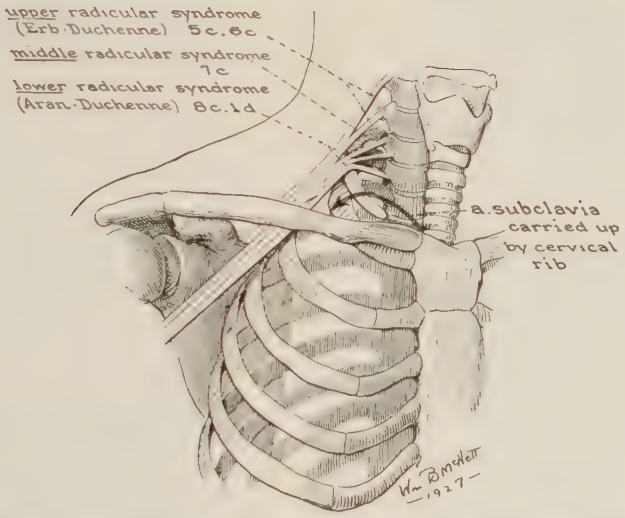


Fig. 299.—Types of brachial palsy. Upper radicular or Erb-Duchenne syndrome, middle radicular syndrome, and lower radicular or Aran-Duchenne syndrome.

(c) *Lower-arm Type (Aran-Duchenne Syndrome, Klumpke Paralysis).*—This results from injury of the eighth cervical and first dorsal nerves. There is numbness and anesthesia of the ulnar side of the forearm and hand, and paralysis of the intrinsic muscles of the hand *(claw-hand)*. Inability to grasp may be associated from paralysis of flexors of the wrist and fingers. Horner's syndrome may be present.

Etiology.—*Trauma:* Traction upon the arm in adduction tends to separate the shoulder from the head, and to strain or rupture the upper cervical nerves, the sixth and seventh, with paralysis of the upper arm type as in brachial birth-palsy. With a cervical rib elevating the plexus in the neck, or a post-fixed plexus, one which has a lower origin than normal, traction upon the adducted arm may cause a lower-arm or Klumpke type of paralysis from pressure or tension upon the lower cords (the eighth cervical and first dorsal).

Prognosis depends upon the severity, the extent of the lesion, and the after-treatment.

Treatment.—In brachial birth-palsy the deformity should be overcome by putting the arm in a position of abduction and external rotation, to relax the paralyzed muscles and prevent contraction and flail shoulder; a plaster, wire, or aluminum aëroplane splint should be fitted, and daily massage and passive movements used. If there is no evidence of improvement within three months, the brachial plexus may be explored and an attempt made to unite the divided

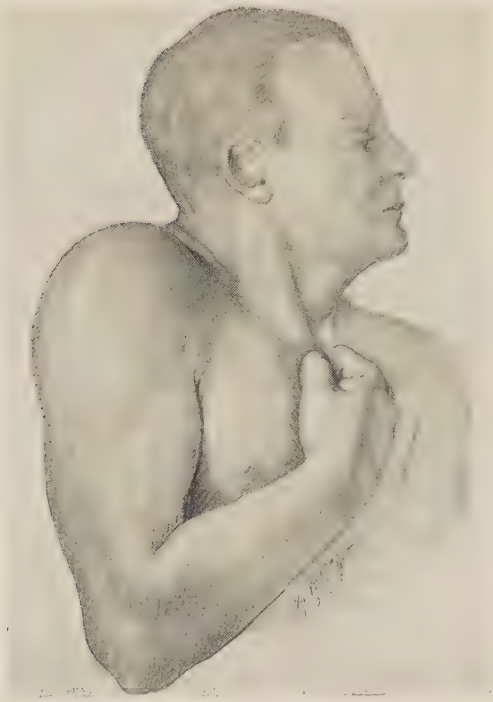


Fig. 300.—Illustrating method of obtaining relaxation of the brachial plexus. The arm is adducted, the shoulder elevated, and the head turned toward the opposite side, giving a slack of 7 to 9 cm. in the plexus of the adult.

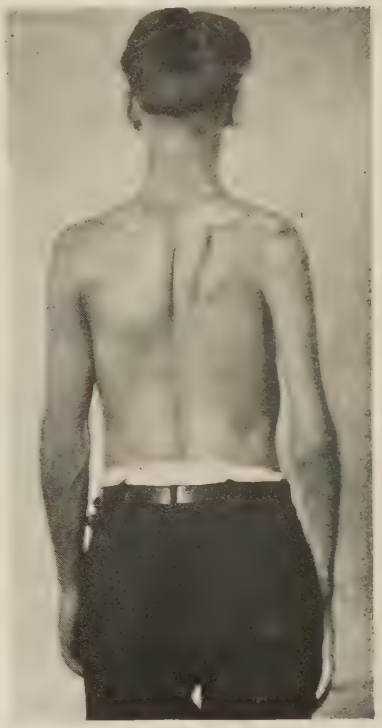


Fig. 301.—Muscular atrophy from paralysis of the right arm and shoulder-girdle caused by supraclavicular rupture of the brachial plexus due to impact of the base of the right neck against a pole in a motor cycle accident.

cords by suture. If the roots have been ruptured within the spinal canal, operation is valueless.

Paralysis from cervical rib is of the lower-arm type, and should be treated by removal of the cervical rib, massage, passive movements, and splints to relax the paralyzed muscles and prevent the development of claw-hand.

Long Thoracic Nerve (*External Respiratory Nerve of Bell* [5, 6, 7 C.]).—This supplies the serratus anterior and, when injured, *scapula alata* (*winged scapula*) follows. The paralysis interferes with the raising of the arm, in front of the

body, above the level of the shoulder, and also with forward pushing movements. When the arm is raised the inner edge of the scapula protrudes, the lower angle becoming prominent and approaching the middle line. The nerve, together with the third and fourth cervicals, may be injured in the lower part of the neck by carrying weights upon the shoulder, or in the axilla and on the side of the thorax in operations for cancer of the breast; or by gunshot or other injury.

Treatment.—If the nerve has been contused or bruised, the serratus should be relaxed and placed at rest by a sling for the elbow, daily massage given, galvanism and passive movement used. As a rule, recovery follows. If the nerve has been divided or if the paralysis persists, the nerve may be exposed by operation, the divided ends sliced back to healthy fasciculi and united by suture, or the distal end may be grafted into the posterior cord of the brachial plexus. As a substitute operation, the sternocostal portion of the pectoralis major may be transplanted to the lower angle of the scapula.

Axillary (*circumflex*) **nerve** (5, 6 C.) supplies the deltoid and teres minor. As the axillary nerve winds around the neck of the humerus, it may be hurt by crutch pressure, subglenoid dislocation, fracture of the neck of the humerus or scapula, pressure or disease of the subdeltoid bursa, or a direct pressure on the terminal filaments of the nerve during certain work, such as that of printers. The deltoid is paralyzed and becomes wasted, the acromion unduly prominent, and the arm cannot be elevated by adjacent muscles. A small area of hypesthesia is usually present over the shoulder.

Fig. 302.—The radial nerve exposed between the heads of the triceps. The tortuous vessel on the sheath shows that the nerve is not under tension.

Suprascapular nerve (5, 6 C.) is damaged in injuries of the shoulder, with paralysis of the supra- and infra-spinati, muscular wasting, and undue prominence of the spine of the scapula. Abduction and external rotation of the arm are impaired.

Musculocutaneous nerve (5, 6, 7 C.) is rarely injured, but if injured the result is a paralysis of the coracobrachialis and biceps, and a sensory loss over the radial side of the forearm. Flexion of the forearm is carried out in pronation by the brachioradialis and the long extensor of the wrist; in a supinated position by the part of the brachialis supplied by the radial nerve.

Radial (*Musculospiral*) **Nerve** (5, 6, 7, 8 C., 1 T.).—This nerve is injured more

frequently than any other peripheral nerve, interruption being followed by paralysis and wasting of the triceps, supinators, and extensors of the thumb, fingers, and wrist. With division in the lower third of the arm or high in the forearm, there may be no sensory loss due to the anastomoses of the cutaneous branches of the radial with the lateral antibrachial cutaneous nerve. If it is divided in the upper third of the arm, there is sensory loss on the dorsum of the hand and thumb toward the radial side.

Etiology.—Crutch pressure (*crutch palsy*), pressure from hanging the arm over the back of a chair (*drunkard's palsy* or *Saturday-night palsy*), pressure from

Fig. 303.—Incision for exposing the musculospiral nerve in the upper part of the arm. For relaxation of the nerve the arm is adducted, the shoulder raised, and the face rotated toward the opposite side.

the head of a second person upon the arm (*honeymoon palsy*) or *pressure or tension during anesthesia* from the arms being extended along the sides of the head. Gunshot wounds or fracture of the neck of the radius may involve the deep branch (posterior interosseus). The radial nerve may be affected in arsenical and lead poisoning.

Symptoms.—There is wrist-drop with the hand in pronation. While the fingers and thumbs cannot be extended, the terminal phalanges are extended by the interossei. With lesions in the axilla, there is loss of extension at the elbow and of supination with the elbow extended, the biceps acting as a supinator with

the elbow flexed. Below the elbow the long supinator and radial extensors escape, and there may only be loss of extension of the thumb and fingers. In lead poisoning the lesion is bilateral, and the brachioradialis escapes.

Prognosis.—Regeneration after suture of the divided radial nerve within one year of the time of injury is usual. Pressure paralysis usually recovers in from a few days to a few months.

Treatment.—During the period of paralysis the extensor muscles of the wrist and fingers should be kept relaxed by a suitable dorsiflexion or "*cock-up*" *splint*, while daily massage, passive movements, and baths are used. The divided nerve should be sutured promptly. Tendon transplantation gives very good results where other measures fail, using the active flexor carpi radialis, the pronator teres, the palmaris longus, and the flexor carpi ulnaris, which are divided near the hand, carried to the back of the wrist, and united to the extensors of the wrist, thumb, and fingers.

Fig. 304.—By freely liberating the radial nerve from adjacent structures, with the arm in adduction, 7 cm. slack is obtained.

Operation.—Incision for the upper or middle part of the arm is along a vertical line from the posterior border of the deltoid to the olecranon, through the brachial aponeurosis, exposing the tendon of the long head of the triceps and the lateral head of the triceps, which are separated to the layer of fascia binding the radial nerve and profunda artery to the humerus. This fascia is carefully divided, exposing the radial nerve. Seven centimeters of slack can be obtained from the medial side by adducting the arm.

For the *lower part of the arm* the incision is oblique, over the groove between the coracobrachialis and the brachialis muscles. The muscles are exposed and separated, and the nerve found in the groove between.

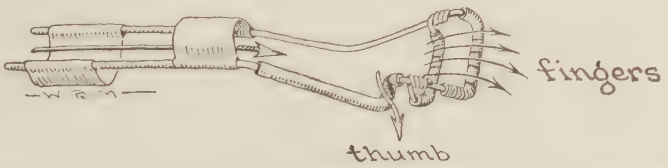


Fig. 305.—Buerki's cock-up splint improvised of wire, rubber tubing, and strips of canvas, useful in musculospiral paralysis. After injury to a peripheral nerve it is important to maintain relaxation of the paralyzed muscles until the power of voluntary contraction has returned.

Median nerve (6, 7, 8 C., 1 T.) *in the forearm* supplies both pronators and all the flexors except part of the flexor profundus and the flexor carpi ulnaris; *in the hand*, it supplies the abductor pollicis brevis, opponens pollicis and flexor pollicis brevis, and the first and second lumbricales.

Fig. 306.—Babcock's operation for rerouting median nerve below the elbow to overcome a large gap. A large adherent neuroma of the ulnar nerve is shown involving the lower third of the forearm.

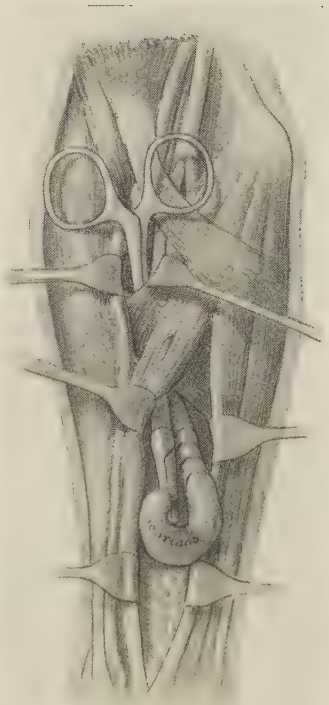


Fig. 307.—Operation for rerouting median nerve. The neuroma and adjacent portions of the nerve-trunk have been freed from adhesions and the neuroma grasped by forceps passed between the heads of the pronator teres preparatory to withdrawal.

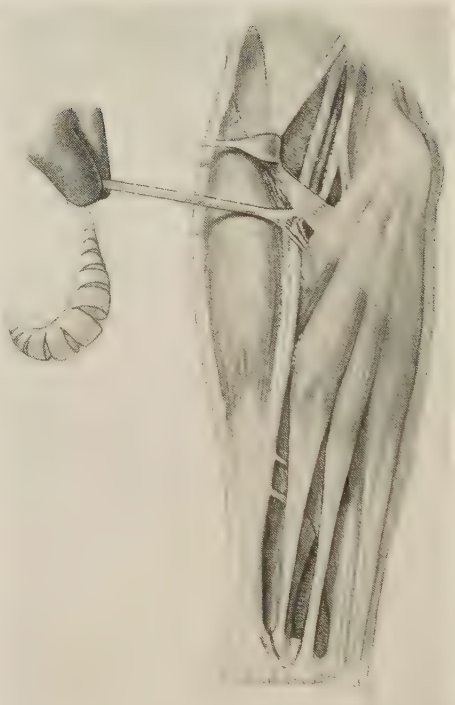


Fig. 308.—Rerouting median nerve. The proximal portion of the median nerve has been withdrawn from its deep muscular position at the elbow. The upper muscular branches interfering with displacement of the nerve at the elbow-joint are shown.

Symptoms.—Injury at the level of the elbow or upper arm produces paralysis with loss of pronation of the forearm, weakened flexion at the wrist with ulnar deviation, loss of flexion of all interphalangeal joints except the two dis-

Fig. 309.—Expedients used in liberating median nerves at the elbow. The sheath overlying the muscular branches *a* and *b* of the main trunk of the nerve is split and the muscular branches stripped back so that they are given off from the main trunk at a higher level. The main trunk is liberated from the restraining branches by the expedients shown in 2, 3, 4, 5, and 6. In this way the median nerve is liberated to a point well above the elbow-joint and may be brought to a subcutaneous position. Such liberation does not prevent conduction. The contractile power of the pronator teres should be present immediately after the operation.

tal joints of the two ulnar fingers, and of anterior adduction of the thumb. At the level of the wrist, thumb movements, especially abduction, are affected by the paralysis of muscles of the thenar eminence. Sensory loss on the

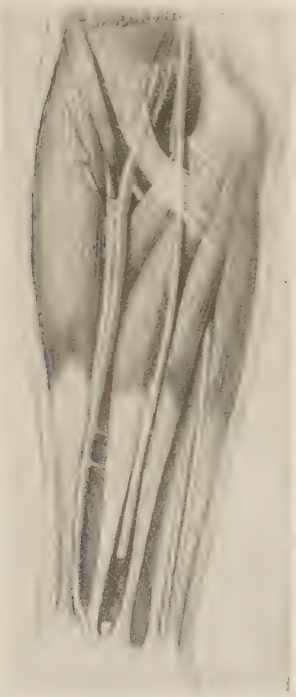


Fig. 310.—Rerouted median nerve in its new superficial position.

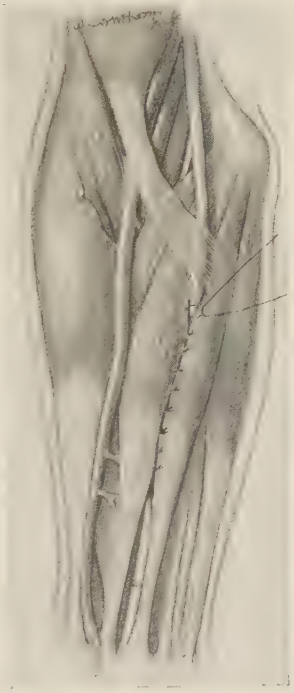


Fig. 311.—The united and transplanted median nerve is covered in its superficial position by the palmaris longus and the flexor carpi radialis.

palmar aspect involves the three and a half radial fingers; on the dorsum, the last two phalanges of the index and middle fingers and the radial half of the fourth finger. Deep sensibility is retained.

Etiology.—Usually wounds of the palmar surface of the wrist, forearm, and arm. In occupational palsy an associated lesion of the ulnar nerve is usual.

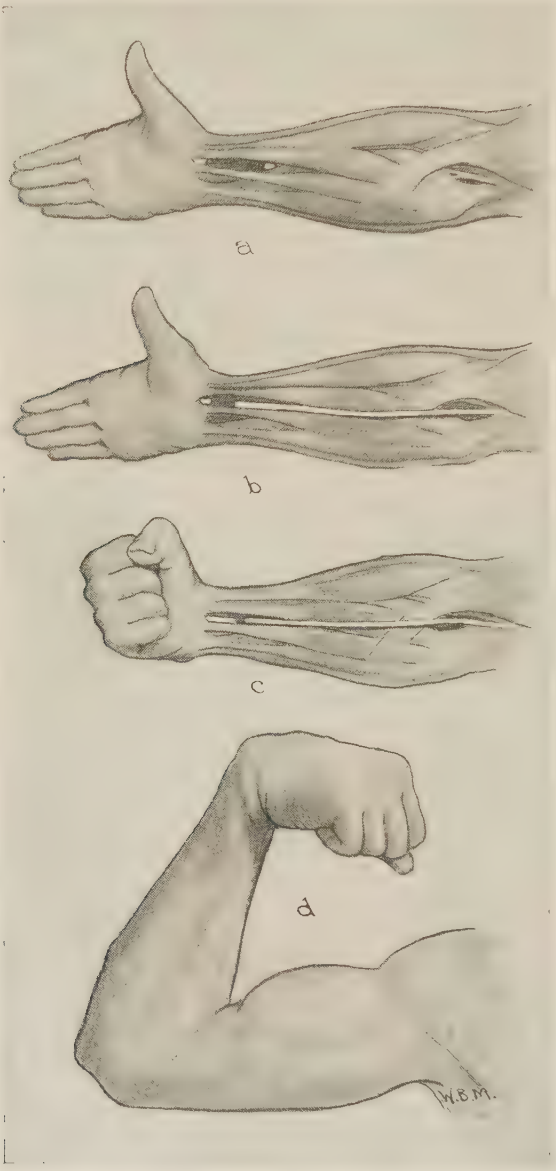


Fig. 312.—Steps in the operation for overcoming large defects in the median nerve: (*a*) Defect in nerve in lower third of forearm. (*b*) Transplantation of median nerve to superficial position in the upper forearm. (*c*) Overcoming 5 cm. of the gap by flexion of the wrist. (*d*) Overcoming residual gap by flexion at the elbow.

Diagnosis is made by the area of anesthesia and the inability to appose the thumb to the finger tips without touching the palm, due to paralysis of the abductor pollicis brevis and opponens pollicis.

Prognosis.—Regeneration after suture may be slow and variable, and the nerve should be reëxplored if there is no evidence of improvement within four months after operation.

Large defects in the median nerve in the arm are overcome by taking up the slack produced by adduction of the arm and acute flexion of the forearm. In the forearm the gap is closed by acute flexion at the elbow and wrist. If more slack is necessary, the proximal end of the nerve may be withdrawn from between the heads of the pronator teres, and rerouted under cover of the palmaris longus (Babcock).

Ulnar nerve (8 C., 1 T.) supplies the flexor carpi ulnaris, the ulnar half of the flexor digitorum profundus, all the interossei, the third and fourth lumbricales, the small muscles of the little fingers, the muscles of hypothenar eminence, and the adductors and inner head of the short flexor of the thumb.

Etiology.—The ulnar nerve usually is injured by wounds or dislocations of the elbow.

Symptoms.—If the injury is at or above the elbow, flexion of the wrist is feeble, incomplete, and with radial deviation. The wrist hyperextends on straightening the fingers, and the fingers are extended at the metacarpophalangeal joint and flexed at others. This is less marked in the index and middle fingers owing to the active lumbricales. There is loss of movement of the little finger, and inability to separate the flexed fingers or to adduct the wrist.

Fig. 313.—Muscular atrophy of thenar and hypothenar muscles from division of median and ulnar nerves.

Lesions at the level of the wrist are followed by "claw-hand" (*main en griffe*) from escape of the flexor profundus digitorum and the unopposed action of the long flexors and extensors, with abduction of the thumb. There is wasting of the hypothenar eminence, the interosseous spaces, and between the thumb and index finger. The sensory loss involves the fifth and the ulnar half of the fourth finger, including the pulp and nail.

In lesions below the dorsal branch the sensory loss is less extensive. Deep sensibility is retained.

Diagnosis.—Paralysis of adductor muscles of thumb, the short muscles of the little finger, with wasting of the thenar and hypothenar eminences, and inability to bring the thumb against the index-finger except in a direction at right angles to the palmar surface (*Froment's prehension sign*) results from ulnar palsy. The last may be simulated by the action of the long flexor or extensor. The grasp of the hand is weakened, with a tendency to radial abduction, from paralysis of

flexor carpi ulnaris and part of the flexor profundus. Anesthesia involves the little and half of the ring finger, and a corresponding dorsal and ulnar segment of the ulnar side of the hand. With division at the wrist, only paralysis in the hand is present and there is no dorsal anesthesia. Deep sensibility is lost only with high division of the nerve, or when the cords in the plexus are divided.

Treatment.—Operations upon the divided ulnar nerve should be performed within five months from the time of injury. Gaps up to $6\frac{1}{2}$ cm. in the nerve below the elbow may be overcome by acute flexion at the wrist, extension of the elbow, and the normal slack and elasticity of the thoroughly liberated nerve. If the gap is greater than $6\frac{1}{2}$ cm., the nerve should be rerouted in front of the elbow-joint from behind the medial condyle. Claw-hand should be corrected by a combination of axial traction and flexion with a special splint.

Fig. 314.—Method of overcoming short gaps in median or ulnar nerve near the wrist by flexing the hand on the forearm.

Obturator Nerve (2, 3, 4 L.).—This may rarely be injured in parturition, in hip-joint disease, by pelvic growths, or obturator hernia.

Symptoms.—Partial loss of adduction of the thigh, one leg cannot be crossed over the other, loss of outward rotation from paralysis of the obturator externus, with pain or anesthesia on the medial side of the lower half of the thigh and knee.

Femoral (*Anterior Crural*) **Nerve** (2, 3, 4 L.).—This nerve is rarely injured alone, but may be damaged by pelvic injury, dislocation or fracture of the femur, wounds of the groin, psoas abscess or abdominal growths, and in parturition.

Symptoms.—Loss of extension of the knee, wasting of the pectineus, sartorius and quadriceps, and absence of knee-jerks. The patient is able to walk with the knee hyperextended. There is pain, paresthesia, or anesthesia of the lower two-thirds of the anterior and medial side of the thigh and the inner side of the leg to the big toe, from interruption of the saphenous. Secondary contracture of the flexor muscles of the thigh occurs. With an injury close to the plexus, the psoas major may be affected, with loss of flexion of the thigh. At a somewhat lower point the psoas escapes and gives flexion, although there is paralysis of the iliacus.

Treatment.—If nerve-suture fails, the flexor muscles of the knee may be brought forward to act as extensors by attaching them to the patella. The biceps on the outer side and the semitendinosus and gracilis on the inner side being transplanted.

Superior Gluteal Nerve (4, 5 L., 1 S.).—When this is interrupted it produces loss of adduction of the thigh.

Lateral Femoral Cutaneous Nerve (2, 3 L.).—Pain or paresthesia on the anterior and lateral side of the thigh from injury of this nerve may be severe, with little sensory loss. While the pain is more frequent in men, it occurs in women during pregnancy, and probably is due to a neuritis from injury to the nerve in its course under the inguinal ligament near the anterior superior spine of the ilium.

Treatment.—To relieve the pain or paresthesia the nerve is injected or resected.

Cauda Equina.—This may be injured in spinal injury, or by blows or falls. Marked sensory symptoms may follow telangiectasis of vessels of the posterior nerve-roots. The sensory loss is of the root type, the protopathic being larger than the epicritic loss, and involves a saddle-shaped area about the anus and buttocks.

The *fourth lumbar* supplies the posterior muscles of the leg below the knee, and the tibialis anterior; the *fifth lumbar*, the anterior leg-muscles except the tibialis anterior and the peronei; the *second sacral*, the glutei and the hamstrings; the *third* and *fourth sacral*, the levator ani, the sphincter, and the perineum.

The cauda equina is frequently defective in low forms of spina bifida, and regeneration after suture is questionable. Although the roots of the cauda equina are medullated, they lie proximal to their supplying ganglia. In case of division, however, suture should be tried. Caudal anesthesia or liberation or resection of the involved posterior roots may be used to give relief from severe persistent pain.

Fig. 315. Showing the gradual sensory improvement after neurorrhaphy. A gap of 12 cm. in the sciatic nerve was overcome with end-to-end suture. Loss of tactile sensation is indicated by dots; of sense of pain, by oblique lines; of deep muscle sense, by crosses.

Sacral Plexus.—This may be involved by pelvic tumors, caries, or inflammation. In parturition the fetal head compresses the higher roots, especially the common peroneal fibers. A sciatic neuritis may spread upward to the plexus.

Symptoms are those of an incomplete sciatic paralysis. The glutei and external rotators of the thigh are affected if the upper roots are involved. If the lower roots are interrupted, anesthesia of the back of the thigh, buttocks, and perineum occurs through the posterior femoral cutaneous (small sciatic) nerve.

Sciatic Nerve.—The sciatic nerve is rarely injured, except by gunshot or deep punctured wounds, fractures of the pelvis or femur, dislocations of the hip, parturition or, in infants, from traction on the legs. In partial division, the lateral or common peroneal portion (external popliteal) is more frequently injured.

Symptoms.—Complete division at the sciatic notch results in paralysis of the flexors of the knee and of all muscles below the knee. If the interruption is below the middle of the thigh, the flexors of the knee escape. There is loss of sensation of the lateral half of the leg and all of the foot, except a small area on the medial side of the dorsum, and wasting of the involved muscles.

Prognosis.—Regeneration of the sciatic is often slow and variable. After injury, if there is no improvement within four months, the nerve should be explored by operation. If half of the nerve has been divided or is the seat of a neuroma, the area should be resected and a *measuring-worm suture* performed. By hyperextension of the thigh, acute flexion of the knee, and the normal slack and elasticity, gaps up to 14 cm. in the sciatic nerve may be overcome with end-to-end suture.

Operation.—The incision is made midway between the tuber ischii and the great trochanter, beginning 3 cm. above the gluteal fold. The gluteus maximus is exposed and retracted upward, and the hamstring muscles relaxed by flexing the knee and retracting mesad, exposing the underlying sciatic nerve.

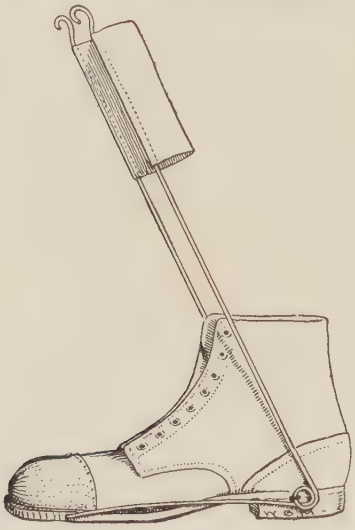


Fig. 316.—Wire spring applied to shoe to overcome paralytic foot-drop.

In the *postoperative treatment* it is especially important to prevent toe-drop by appropriate splint or support. Daily massage, passive movements, and stimulating baths are desirable.

Common Peroneal (*External Popliteal*) **Nerve** (4, 5 L., 1, 2, 3 S.).—Descends on the lateral side of the popliteal space, against the medial surface of the biceps. Below, it curves around the lateral head of the gastrocnemius, between it and the biceps, circling the neck of the fibula under the peronæus longus. It supplies the peronæi, the long and short extensors of the toes, and the tibialis anterior.

Etiology.—Injury in the exposed course of the nerve around the neck of the fibula, wounds of the popliteal space, and prolonged kneeling, when it is nipped by the biceps femoris tendon. In primary neuritis or lead poisoning the tibialis anterior often escapes.

Symptoms.—There is foot-drop, the toes are flexed, and the foot is commonly inverted, producing *steppage gait.* If the tibial nerve is not affected, talipes equinus occurs. The sensory loss involves the lateral half of the front of the leg and the dorsum of the foot to the ends of the proximal phalanges of the toes.

Operation.—A vertical incision is made over the tendon of the biceps which, if necessary, is curved forward over the neck of the fibula, the nerve being located against the mesial surface of the biceps. Care should be taken not to accidentally divide the nerve in its lower portion. Where operation upon the nerve has failed, the foot may be kept raised by cutting the tendons of the tibialis anterior and peronæus longus, fastening them, while taut, in holes bored in the

crest of the tibia at the lower third. Support of the foot is also aided by the removal of an ellipse of skin in front of the ankle, with suture (Jones).

Tibial (*internal popliteal*) **nerve** (4, 5 L., 1, 2, 3 S.) supplies the muscles of the calf and the flexor muscles of the toes, and is less often injured than the common peroneal.

Symptoms.—There is talipes calcaneovalgus with loss of extension of the foot and flexion of the toes, preventing standing on tip-toe; eversion of the foot from paralysis of the peronæus longus, and the final claw-foot from contracture. The disability is slight and the paralysis often overlooked. There is sensory loss of the lateral and posterior surfaces of the lower third of the leg, of the sole, and of all the distal phalanges of the toes.

Diagnosis.—In lesions of the cord or cauda equina the lesions are bilateral, the sphincters are affected, and all the roots are involved below the level of the disease. Where the sacral plexus is involved distribution of the paralysis and the anesthesia is characteristic.

Operation: Vertical median incision is made from the upper portion of the popliteal space downward over the interval between the two heads of the gastrocnemius. The deep fascia is divided, with retraction of the small (short) saphenous vein and sural nerve. The small saphenous vein may be followed to the popliteal vessels, superficial to which is the tibial nerve. The two heads of the gastrocnemius are relaxed by flexing the knee, and are separated by traction.

Neuromata.—Tumors connected with nerves may be true neuromata formed of nerve tissue, nerve-fibers or, rarely, ganglion cells. False neuromata, formed largely of fibroconnective tissue, are much more common.

Plexiform neuromata are multiple tumors of the nerves, due to hypertrophy of the connective tissue. They are often congenital and hereditary, not painful except on pressure, and usually involve the fifth nerve.

Generalized Neurofibromatosis (Von Recklinghausen's Disease, Molluscum Fibrosum).—Plexiform neuromata on nerve trunks, neuro- or myxofibromas, usually in the skin or subcutaneous tissue of the extremities or trunk or occasionally in the spine or cranium, may be single or occur in great numbers, so that hundreds or thousands of growths may appear over the body. They vary in diameter from a few mm. to 2 or 3 cm. The tumors are encapsulated and may easily be removed, but new-growths may continue to develop during the entire life of the individual.

There are also soft, fibrous, sessile, or pedunculated masses in the skin which vary greatly in number and size. These neurofibromas of the cutaneous nerves occur, especially upon the trunk or scalp, and are rare upon the hands and feet. Malignant change and the formation of large growths are not infrequent.

Elephantiasis neuromata are multiple tumors of the nerve-trunks extending to the cellular tissue and skin.

Treatment.—Excision if the growths are painful, disfiguring, or rapidly enlarging.

CHAPTER XXII

THE SKIN AND CUTANEOUS APPENDAGES

THE SKIN

Anatomy.—The skin consists of the outer protective *epidermis, cuticle* or *scarf skin*, and the inner *corium, cutis vera* or true skin.

The **epidermis** from without inward is divided into four layers: (1) *Stratum corneum*, (2) *stratum lucidum*, (3) *stratum granulosum*, and (4) the *stratum mucosum, rete malpighii*, or *germinal layer*.

The **corium** contains vessels, nerves, and lymphatics supported by fibro-areolar tissue. It consists of a superficial (1) *papillary layer*, which has the terminal vascular loops and nerve-endings, and a deeper (2) *reticular layer*, which consists largely of fibro-areolar and adipose tissue.

Lines of cleavage are peculiar to the texture and normal directions of tension of the skin. Wounds parallel with the lines of skin cleavage do not gape, and tend to heal with a linear scar that does not stretch with time. Wounds and incisions across the lines of skin cleavage gape, and the scar resulting may progressively stretch and broaden after healing has occurred. To avoid mutilation and a disfiguring scar, incisions should follow the normal lines of skin cleavage.

Lesions.—The primary lesions of the skin are macules, papules, nodules, wheals, vesicles, and bullæ. Secondary lesions include scales, fissures, excoriations, crusts, ulcers, and scars. These lesions give rise to the following subjective symptoms: Itching, pricking, tingling, formication, hyperesthesia, anesthesia, and burning or stinging pain.

Congenital Anomalies of the Skin include: Ichthyosis, congenital hyperkeratosis of the palms and soles, nevi, fistulas, congenital bands, folds, and fusions. The latter four often require correction by plastic operation.

Purpura (*spontaneous hemorrhage into the skin*) usually indicates a serious toxic condition, and is found in purpura hæmorrhagica, in severe forms of the acute exanthemata as "black smallpox," in rheumatism, from alkaloidal poisons, snake-bite, scurvy, leukemia, and hemophilia.

Henoch's purpura is associated with fever, moderate leukocytosis, vomiting of blood, marked constipation, bloody diarrhea, articular effusions and hemorrhages, abdominal tenderness and rigidity. It has repeatedly been mistaken for appendicitis, intestinal obstruction, mesenteric obstruction, or acute arthritis, particularly when the purpuric rash has appeared late.

Erythema nodosum is characterized by one or several rounded, red, elevated, firm, elastic or soft, deeply embedded nodules, developing on the extensor surfaces of the arms and legs, especially in front of the tibia. These soften and change in color from red to purplish, leave for several weeks a greenish or brownish stain as from a bruise, and may be of streptococcic origin. Fever, malaise, and rheumatoid pains are often associated. It is more frequent in children, in the spring and fall, in association with rheumatism, following

an exanthema, a toxemia, or the use of iodids or other drugs. The tissues show extravasation of white and red cells. Recovery occurs in a month. The condition is often mistaken for a bruise, but the lesions are multiple, often symmetrical, and associated with constitutional symptoms.

Edema of the skin occurs from venous stasis, renal disease, anemia, cachexia, or lymph-stasis. A chronic, dusky red, brawny edema follows recurrent attacks of erysipelas.

Myxedema causes a dry, coarse, thick skin; with subcutaneous mucoid edema; carcinoma with lymphatic obstruction, a painful, persistent watery edema. In lymph obstruction from filaria (*elephantiasis*) the skin becomes thick, rough and coarse, and the subcutaneous tissues blubbery (*pachyderma, cochin leg, Barbadoes leg*).

Pigmentation follows radiation, the application of mustard, blisters, constant pressure as from truss wearing, chronic inflammation, or tattooing. The brownish pigmentation from a mustard plaster may be permanent.

Tattooing consists in the introduction of insoluble pigment (carmine, indigo, vermilion, or cinnabar) into the derma. Some of the pigment particles are carried to adjacent lymph-nodes by leukocytes, but many remain encapsulated in the corium.

Treatment consists in the destruction or removal of the portion of corium containing the pigment. This may be done with a sharp razor, and Thiersch's grafting used. A saturated solution of tannin (Variot) or a 40 per cent. solution of zinc chlorid (Brault) may be tattooed into the part with fine needles. After using the tannin, the part is rubbed with a stick of nitrate of silver. Pustulation, with the expulsion of granules, may also be produced after multiple needle punctures by applying a 1 : 300 solution of mercury bichlorid.

Paraffinoma.—Hard and soft paraffin have been injected under the skin for cosmetic effects; about hernial openings in the attempt to cure hernia; and placed within the meninges or poured into the peritoneal cavity to prevent adhesions. In each location the use of the paraffin or paraffin oil produces undesirable secondary symptoms.

Infection, abscess formation, and necrosis may follow; or a secondary slow inflammatory process with proliferation of fibroblasts, endothelial and plasma-cells, and often the formation of endothelial giant-cells resembling those found about other foreign bodies. After from three months to a number of years the paraffin may gravitate to a more dependent situation; become irregular, lumpy, or surrounded by fibroconnective tissue, the overlying skin becoming indurated, red, purplish, or telangiectatic. The disfiguring masses are called *paraffinoma*.

In serous membranes, fibroconnective tissue adhesions form from the mechanical irritation of the oil or solid wax. After injection for hernia, the hernia usually promptly recurs, and the mass of paraffin often causes painful pressure. It is obvious that paraffin or paraffin oil should not be employed within the tissues.

Treatment.—The removal of paraffinoma may be difficult, the fragmented paraffin being intimately held in new formed connective tissue. It is necessary to excise portions of the subcutaneous tissue and, at times, part of the overlying stretched and infiltrated skin. Repeated operations may be required, and the in-

sertion of grafts of fat or connective tissue desirable to fill the subcutaneous defect left after the removal of the paraffin. The paraffin should not be removed by incisions through mucous surfaces, as from the inside of the mouth, as troublesome hematomas and infections follow.

Keratosis senilis (*seborrheic patch*), a greasy, yellowish-brown, plaque-like thickening of the epidermis; occurs on the skin of the face or hands in the aged from exposure. It is a precancerous lesion. Keratosis also follows radiation by ultra-violet rays, the Roentgen ray, or radium.

Treatment.—The repeated application of a solution of sodium ethylate. For resistant lesions, cauterization with trichloracetic acid, or excision and skin-grafting may be necessary.

Callosity (*tyloma, callositas*) is a localized hyperplasia of the epidermis producing a callus, clavus, or corn.

Treatment.—Relief from pressure, paring or excision, or the application of 20 per cent. salicylic acid in ointment or collodion.

Corn (Cornu).—A local hyperplasia of the keratin layer of the epidermis, with a hard nodular depressed center making painful pressure upon the papillary layer of the skin. Corns are due to intermittent pressure, chiefly about the toes and feet, from loose, tight, or badly fitting shoes. They especially occur over bony prominences.

Varieties.—(1) *Hard*, when not macerated; (2) *Soft* or macerated, those occurring between the toes or kept moist by perspiration. In a bunion an inflamed bursa underlies the callosity.

Treatment.—(1) *Excision:* With a very fine, very sharp knife the edge of the corn is raised, and accurately following the fine white line marking the junction with the papillary layer, the corn is carefully dissected out with its underlying prominences and irregularities. Unless the papillary layer is entered there is no hemorrhage. (2) *Application of salicyclic acid* in ointment or collodion (5 to 20 per cent.). (3) *Relief of pressure* by pads or corn-plasters. (4) Avoidance of maceration of soft corns by ventilation and separation of the toes.

Cornu cutaneum or *horn* occurs in the aged, chiefly about the face. Horns grow from sebaceous cysts, warts, or scars. The treatment is removal, with destruction of the base by excision or caustic.

Hypertrichosis (Superfluous Hair, Hirsuties, Polytrichia).—A condition of excessive or abnormal hairiness may be congenital or acquired; of limited or diffuse distribution. Deviation of the hairs from their normal direction (*trichiasis*), or an abnormal double row of hairs (*districhiasis*), is disfiguring and produces on the eyelids irregular double lashes and irritation of the cornea.

Etiology.—Irritation and local hyperemia, including sun-burn, shaving, and the application of mineral or animal fats to the skin have little or no influence upon the growth of hair (Trotter). Marked precocious hypertrichosis occurs with tumors of the adrenals.

Treatment.—1. *Electrolysis* (Michel): A very fine steel or platinum needle, attached to the negative (alkaline) pole of a galvanic battery, is introduced into the hair-follicle through the papilla, and a current of 1 to 3 milliamperes applied for a few seconds until bubbles of gas appear at the follicular orifice. The large, wet, positive (acid) electrode is applied to the hand or other indifferent

part of the body. If properly used, the hair should immediately loosen and be readily removed. To prevent scarring, excessive current, prolonged application, or the removal of closely adjacent hairs at the same sitting should be avoided. Electrolysis is a delicate, tedious, and rather painful procedure, requiring many sittings if the hairs are numerous. Minute white scars may remain, and from one-third to one-tenth of the hairs recur, dependent upon the skill of the operator.

2. *Radiation Depilation:* Loss of hair follows the action of the Roentgen rays and radium. If the structure of the skin is not seriously damaged, the hairs return. If the hair-follicles are permanently destroyed, associated atrophy of the skin, dermatitis, telangiectasis, and keratosis are prone to occur. Depilation by radiation, therefore, should only be considered for the temporary removal of hairs, as in the treatment of certain parasitic skin diseases.

3. *Chemical depilatories* temporarily remove hair, which later returns in coarser form. They usually consist of combinations of barium sulphid, as: Fresh barium sulphid, 8 to 16 gm.; zinc oxid, starch, of each sufficient to make 30 gm. For use, the powder is made into a paste with water, applied for several minutes until the hairs may be scraped away by a dull edge, the part then being washed, and a soothing cream, ointment, or lotion applied.

Small localized hairy growths, as hairy moles, may be destroyed by caustics. The disfigurement of hypertrichosis is reduced by removing the fat from the hairs by ammonia water, and bleaching with peroxid of hydrogen (Buckley).

Alopecia (*baldness*) may be due to heredity, age, toxemia, local injury, inflammatory or parasitic disorders. It follows nineteen days after the internal use of 8 mg. of thallium acetate per kilo of body weight.

Treatment.—For local disfiguring losses of hair, as of the eye-brow or parts of the bearded face, a plastic operation may be done with the transplantation of a pedicled hair-containing flap from the scalp, or tattooing used.

Rhinophyma (**Potato Nose**).—From the long-continued congestion and irritation of acne rosacea, hyperplasia of the skin of the tip of the nose may occur, forming a firm, reddish or purplish, lobulated or pendulous mass. The lesion should be pared off by a sharp knife, under local or general anesthesia. The epidermis soon regenerates, and usually only slight scarring follows.

Telangiectasis, when disfiguring, may be treated by punctate cauterization, electrolysis with the electric needle, or destruction by fuming nitric acid or other cauterant.

Perforating ulcer (*malum perforans*) is an indolent chronic deep ulcer, usually occurring on the plantar surface of the foot.

Etiology.—Tertiary syphilis (especially neurosyphilis, tabes, and general paralysis), diabetes, chronic arteriosclerosis, and leprosy favor the condition. The patient usually is a middle-aged or elderly man. The process begins with indolent suppuration under a callus or corn, the ulcer becomes deep and narrow, the skin-margins are thick, callous, and overhanging, and there is usually little pain or tenderness:

Treatment.—The surrounding callus should carefully be excised, the sinus stimulated by the application of tincture of iodin, kept clean, and filled with 50 per cent. red iodid-of-bismuth paste. The ulcer is resistant to treatment.

Ainhum.—An annular constriction of one or more toes or, less frequently,

the fingers; progressing to spontaneous amputation in from three to ten years, occurring usually at the junction of the first and second phalanges. The disease is more common in the tropics and in negroes. There is hyperkeratosis, acanthosis, and obliterative endarteritis. Secondary ulceration occurs in the groove.

Treatment.—Incisions to divide the constricting band, or amputation.

Furuncle or Boil.—An acute, conical, inflammatory, suppurative, cutaneous lesion, due to a staphylococcus. It chiefly involves the skin rather than the subcutaneous tissues, and frequently is multiple (*furunculosis*).

Etiology.—Adolescence and middle life, especially in males. The infection enters by a hair-follicle or sweat-gland. Auto-infection with satellite or distant boils is common, the discharge being spread by poultices or dressings, the clothing or hands. Furunculosis often is associated with diabetes, gout, nephritis, scrofula, or eczema. A *blind boil* is one that does not tend to point and discharge.

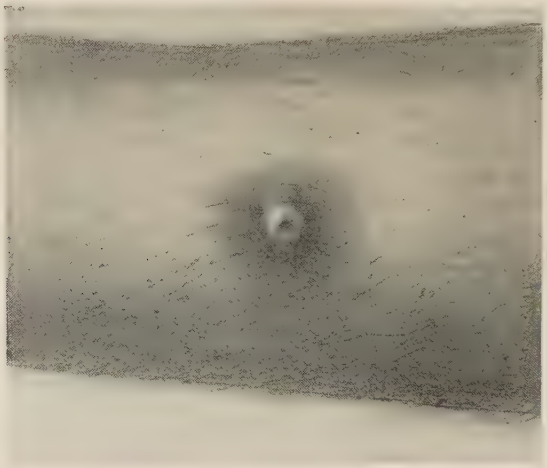


Fig. 317.—Furuncle of the arm.

Symptoms.—A boil begins as an itching, reddish papule which enlarges and becomes tender, painful, and conical. A greenish slough forms in the center, the apex becomes yellow from *pointing*, and greenish-yellow pus escapes, the slough or core separates and is finally expelled, and the cavity is obliterated by granulation.

Diagnosis.—A carbuncle is single, larger, deeper, has multiple openings, and is dome shaped; while a pustule is smaller, more superficial, and contains liquid pus instead of the central greenish slough.

Prognosis.—Successive "crops" of boils frequently occur from the patient's constitutional condition, or from neglect of antiseptic precautions.

Treatment.—1. Constitutional treatment and diet should be given for any associated diabetes or nephritis. Full doses of tincture of chlorid of iron may be used internally, and sodium cacodylate and staphylococcus vaccine (autogenous preferred) subcutaneously. The internal use of yeast has been repeatedly advocated. Frequent tub-baths, containing 30 gm. of chlorid of lime and 60 gm. of carbonate of soda to each 100 liters of water, to disinfect the skin and prevent

dissemination are valuable. Dressings and clothing contaminated by the discharge should be burned or sterilized.

2. *Local.*—(a) *Abortive treatment* is used before suppuration has started. The injection by a fine hypodermic needle of 1 to 3 ♏ of liquefied phenol into the center of the furuncle, followed by the local application of *unguentum hydrargyri oxidum flavum* will often arrest the infection. (b) For a fully developed boil, not spontaneously discharging, *incision* and *drainage* with the frequent disinfection of adjacent skin by ethyl alcohol is desirable. Poultices spread the infection. The local application of compound resin cerate facilitates liquefaction and softening. (c) With the *expulsion or removal* of the separated *core*, healing usually rapidly follows under a dressing of 10 per cent. balsam of Peru in resin cerate.

Carbuncle.—A massive, acute, inflammatory, necrotic, and suppurative lesion of the skin, with the formation of a large elevated mass, and pointing through the columna adiposæ by several openings.

Site.—Occurs only where the skin and subcutaneous tissues are dense and thick, as the back of the neck, back, buttocks, and face.

Pathology.—Swelling, infiltration, and exudation occurs in the dense cutaneous and subcutaneous fibroconnective tissue, followed by necrosis, with the formation of a large central slough or of a core of greenish-yellow color. The adjacent tissues gradually liquefy, and the central slough separates in two or three weeks. When fully developed, there is from within out: (1) Central slough; (2) a layer of pus and abscesses; (3) granulations; (4) inflamed infiltrated tissue.

Etiology.—*Staphylococcus pyogenes aureus* entering a sebaceous or hair-follicle. A furuncle in dense skin may be exacerbated into a carbuncle by squeezing or other traumatism. Carbuncles usually occur on the back of the neck in elderly obese men, especially those with diabetes, nephritis, or other debilitating conditions.

Symptoms.—A dome-shaped inflammatory elevation of the skin, from 3 to 15 cm. in diameter, which is red, brawny, very painful, tender and, at times, vesiculated. After one or two weeks grayish or yellowish points appear, which slowly liquefy and coalesce, with a discharge of pus and greenish-yellow sloughs of subcutaneous tissue. After three to six weeks, the pus and slough having been expelled, granulations line the cavity, which contracts, and healing occurs.

Complications.—(1) Secondary adjacent (satellite) boils, particularly when poultices or macerating dressings are applied, from infection entering the adjacent hair-follicles. (2) Septicemia, pyemia, acid intoxication, and uremic coma occur, and may be fatal.

Diagnosis.—Furuncles are small, conical, often multiple, and have but one opening. Gummata are associated with little tenderness or pain, are indolent and have a "wash-leather" center, and gummy or thin pus instead of a thick purulent discharge. *Anthrax* is associated, with but little local pain or tenderness. Vesicles appear, followed by a central black slough, peripheral vesicles and much swelling and edema occur without suppuration, and the anthrax bacillus is found in the tissue.

Treatment should include careful attention to the underlying constitutional condition. (1) *Abortive treatment* similar to that used for furuncles may be tried for small beginning carbuncles. For fully developed large carbuncles (2)

circular excision to the deep fascia or muscle under nitrous oxid or ethylene, followed by packing with moist antiseptic gauze, is indicated. No sutures or ligatures are used. Excision eliminates the long period of necrosis and suppuration, reduces septic absorption, gives prompt relief from the severe pain, and leaves a large wound which usually rapidly closes by granulation. The first gauze packing is not removed for three days. (3) *Caustic destruction*, by sticks or paste of caustic potash, is slower and more painful than excision. (4) *Concentric adhesive-plaster strapping* (O'Farrel, 1858), leaving a small central opening for the escape of discharges, has been used for carbuncles of moderate size. Warm antiseptic fomentations favor liquefaction and the escape of slough. Disinfection of the surrounding skin by frequent alcohol sponging and the application of the yellow precipitate ointment is important.

Carbuncle of the upper lip gives a mortality of 20 per cent. from secondary intracranial infection through the facial and cranial veins. Early excision by a very sharp knife, without squeezing, suture, or manipulation, and with absolute rest in bed, is desirable.

Granuloma pyogenicum (*botryomycosis hominis*, *granuloma telangiectodes*) is a small, persistent, pedunculated granuloma developing at the site of an injury from infection by the *Staphylococcus aureus* (Poncet and Dor, 1897). The reddish, purplish, pedunculated, tender and painless, hemorrhagic growth appears after injury upon the hands, feet, or face. It rapidly develops, reaches the size of a pin-head or cherry, promptly recurs after excision, persists for weeks or months, and consists of newly formed vascular connective tissue.

Treatment.—Excision or thorough cauterization by carbon-dixoid snow, zinc chlorid, copper sulphate or fuming nitric acid, followed by the application of yellow precipitate ointment.

Progressive gangrenous infection of the skin usually follows drainage of a peritoneal infection. The wound margins become deep red or purple, with superficial edema; the adjoining skin showing a less intense erythema. A progressive subcutaneous necrosis occurs, and the cutaneous margins become dark gray or black, and progressively slough. The lesion may be exceedingly sensitive, and often is fatal. The process progressively involves the skin and subcutaneous tissues, often to the deep aponeurosis, and resists the ordinary antiseptics, drainage, irrigation, Dakin treatment, or radiation.

Treatment.—(1) Constant fomentation with hot saturated permanganate of potash solution. (2) Exposure to ultraviolet rays. (3) Cauterization of the advancing margins with 10 per cent. zinc chlorid solution or the actual cautery. (4) Two cases were arrested by excision and packing for twenty-four hours with 1 per cent. solution of formalin on gauze (Brewer and Meleney).

Veldt sore begins in an abrasion of the epidermis, such as from a blister from the rays of the sun, the bite of an insect, or a scratch. This is followed by a pustule which ruptures, and a brownish-yellow scab forms, under which there is an indolent persistent ulcer. The sore usually is found upon the hands, arms, neck, or feet in those who have neglected bathing and who have lived on canned food.

Treatment.—Local cleanliness, application of a 50 per cent. iodid of bismuth ointment, and the use of a varied vitamin-containing diet.

Tuberculosis Cutis (see page 158).—*Lupus vulgaris* usually involves the skin of the face of young women. Reddish superficial nodules develop in the

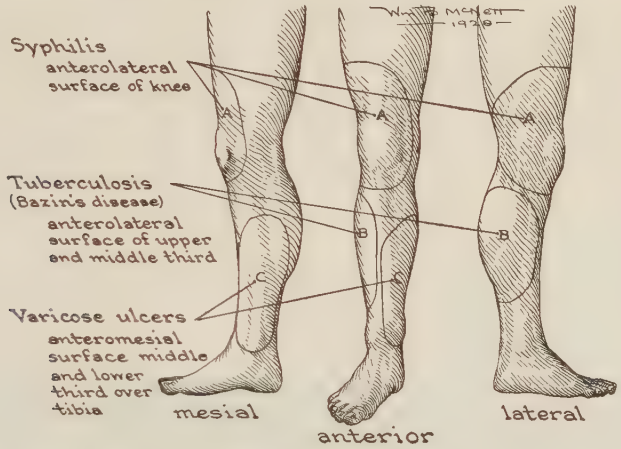


Fig. 318.—Usual sites for syphilitic, tuberculous, and varicose ulcers on the leg.

corium, coalesce, and advance at the periphery, while healing with a thin white scar in the center. The tubercles on pressure by a glass slide resemble drops of apple jelly (*apple-jelly nodules*). There is no induration either with ulceration (*lupus exedens* or *lupus ulcerans*) or without ulceration (*lupus non-exedens;* when scaly, *lupus exfoliativus*), and the lesion is superficial, the outline rounded.

Fig. 319.—Syphilitic ulcer. Sharply marginated punched-out ulcers along the advancing edge with evidence of central healing and a superficial pigmented scar. Associated loss of voice. Positive Wassermann reaction. Rapid healing following injections of arsphenamin. (Stokes.)

Verruca necrogenica (*dissecting porter's wart, butcher's wart, anatomic tubercle*) results from the inoculation of the tubercle bacillus through abrasions of the skin, usually in butchers, cattlemen, and those who handle dead bodies. A small warty mass with pustules occurs, which should be treated by a 5 per cent. creosote or guaiacol ointment or by cautery destruction.

Scrofuloderma or **tuberculous gumma** usually follows a subcutaneous tuberculous lymphadenitis, with secondary caseation and ulceration of the skin. The treatment is that of tuberculous lymphadenitis.

Erythema induratum (*Bazin's disease*, 1855) is a paratuberculous infection involving the skin, usually occurring in association with a tuberculous lymphadenitis in growing girls. Dusky red nodules appear upon the legs, followed by small superficial indolent ulcers. Healing follows improvement in the general

health, or may rapidly occur after the use of tuberculin. Locally bismuth paste or a varnish of compound tincture of benzoin, containing 3 per cent. of guaiacol, is of value.

Sporotrichosis.—The dermal lesion of sporotrichosis is illustrated on page 178.

Blastomycosis.—*Blastomycetic dermatitides* begin as papules which become pustular, papular, or verrucose. The margins of the lesion are raised, dusky red, and contain miliary abscesses. There is brownish crusting, and secondary areas of pyogenic infection and a parchment-like scar-tissue from healing may occur. The lesions have a penetrating and nauseating stench.

Treatment (see page 176).

Sebaceous cysts (*steatoma*, *wen*, *retention cysts* of sebaceous glands) are rounded, well-encapsulated cysts that may reach the size of an egg or orange, and occur on the scalp, face, chest, back, neck, and are rare below

Fig. 320.—Blastomycosis of the leg. The papillomatous border eliminates syphilis. (Stokes.)

the level of the navel. Often they are multiple. The enlarged orifice on the skin is marked by a black dot. The contents are cheesy and often malodorous sebum. Inflammation and suppuration are frequent, especially after middle age. Secondary horn formation or carcinomatous change is an occasional complication.

Treatment.—Enucleation. Recurrence will follow if all of the cyst wall is not removed.

Pilonidal Cysts and Fistulæ.—Sequestration cysts containing hair usually develop over sacrum and coccyx or, infrequently, on the bridge of the nose. The hairs may invade the tissues during postnatal life, and suppuration with sinus formation usually occurs in early adult life. The condition is associated with hirsutism.

Treatment is free excision, the wound being either sutured or, if over the sacrum, packed and caused to close by granulation. During healing the adjacent skin should be closely shaved.

Molluscum Contagiosum.—Yellowish-white nodules about the size of a

pea, develop in the skin of the face or, more rarely, other parts of the body. The nodule consists of a central core of epithelial cells, supported by a fibrous stroma, is locally contagious, and should be excised.

Verrucæ (*warts*) affect the hands, face, scalp, and neck. They develop from local irritation, rarely become malignant, and appear and disappear without apparent cause. Infection is a causal factor.

Treatment.—Sodium ethylate solution, made by dissolving metallic sodium in alcohol, applied several times daily. Cauterization with fuming nitric acid, acid nitrate of mercury, trichloracetic acid, fulguration, or excision may be used. Incomplete removal is followed by recurrence.

Venereal warts occur about the genitals and anus from irritating discharges, and should be treated by cleanliness, correction of local infection, application of nitrate of silver and a dusting-powder, such as: Salicylic acid, 1 part; boric acid, 10 parts; calomel, 15 parts; bismuth subnitrate, 25 parts.

Angioma (see page 193).

Capillary nevus (*port-wine stain, nevus flammeus*) forms patches of irregular size from a pale pink to a deep plum color, usually upon the face or upper part of the body, occasionally upon the mucous membranes. It may increase in size with the growth of the child, may show active growth at puberty, and in certain cases partially or completely involute. It produces no symptoms except the disfigurement.

Cavernous hemangioma (*raised hemangioma, strawberry birthmark, fungus hematoma, spongy aneurysm*) forms bright red to deep purple, raised, soft, compressible masses, chiefly upon the face and scalp of newborn children. After increasing in size for months, they usually disappear spontaneously about the end of the second year, leaving only an atrophic or pigmented patch, or a fibrovascular mass (*nevus lipomatodes*).

Fig. 321.—Fibroma molluscum involving the trunk, left buttock, and upper thigh removed by excision with a plastic closure.

Fibroma molluscum and fibroneuromas not infrequently involve the skin.

Treatment.—Excision and plastic closure.

Sarcoids are circumscribed, often encapsulated, small benign tumors of the skin, which usually respond to arsenical treatment. In the *multiple sarcoid of Boeck*, yellowish or reddish nodules of epithelial cells, separated by connective-tissue septa, appear upon the skin of the face or extremities, and, after persisting for months or years, disappear with or without the use of arsenic. With the

Spiegler-Fendt sarcoid, dark red or purplish nodules develop on the skin of the breast, trunk, and arms, composed of round cells and occasionally epithelioid or giant-cells. They resemble a lymphogranuloma, and necrosis and ulceration may occur, giving rise to lesions suggesting tuberculosis or syphilis. The subcutaneous *sarcoid of Darier-Roussy* and *erythema induratum* or *Bazin's disease* are tuberculous lesions.

Treatment.—Arsenicals by intravenous injection.

Sarcoma cutis occurs as: (1) Localized, non-pigmented sarcoma. (2) Multiple cutaneous sarcoma. (3) Melanotic sarcoma.

1. **Local non-pigmented sarcoma** forms a rounded, reddish or purplish, soft, compressible or pulsatile growth, usually developing at the site of a previous in-

Fig. 322.—Multiple hemorrhagic sarcoma of Kaposi (Kaposi).

jury, wart, or nevus. The growth may remain local and relatively benign; or may show delayed or early generalization, with the development of great numbers of growths over the skin, and early death.

2. **Multiple hemorrhagic sarcoma** (*idiopathic multiple pigmented sarcoma of Kaposi*, 1872) usually appears in men with the formation of a number of doughy or firm, reddish or purplish nodules with associated telangiectases. The tumor consists of round- or spindle-cells. It begins as an angioma, followed by proliferation of connective tissue and endothelium, and probably is primarily inflammatory. The nodules usually involve the legs, may persist, ulcerate, and be fatal after two to twenty years, or spontaneously disappear. Arsenicals have been very useful in certain cases.

3. **Melanoma** (*melanotic sarcoma, melanotic epithelioma*) consists chiefly of

pigmented cells which may be of epiblastic or mesoblastic derivation, usually developing in a pigmented mole or nevus. The tumor occurs on the face, extremities, and soles of the feet, and often grows rapidly after local traumatism or excision. Multiple secondary growths appear in the skin, subcutaneous tissues, and internal organs, and rapidly prove fatal.

Treatment.—Deeply pigmented moles and nevi, showing a tendency to local irritation or growth, should be treated by thorough cautery destruction, followed by wide excision and suture. With the development of secondary nodules, excision and local destruction are useless; but an effort may be made to prolong life by radiation, the use of Coley's mixed toxins, the injection of large doses of arsenicals (1 to 4 gm. of sodium cacodylate given intravenously or subcutaneously), or the intravenous injection of the colloidal metals may be tried.

Basal-cell Cancer, Rodent Ulcer, Jacob's Ulcer, Hairy Matrix Cancer, Cancroid (Krompecher, 1900).—Malignant tumors of the skin arising from the

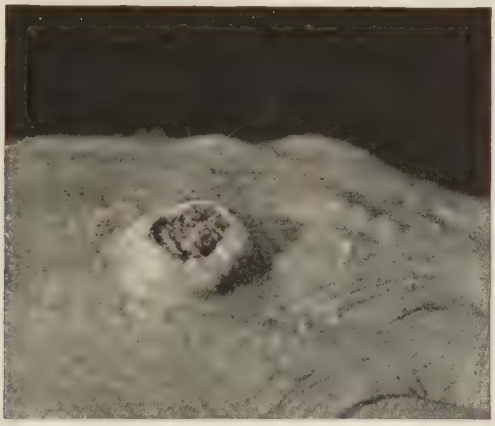


Fig. 323.—Basal-celled epithelioma of the hand, showing the elevated rolled, pearly border (Stokes).

basal layer, fetal epithelial rests under the skin, or hair-follicles, sweat- or sebaceous glands.

Etiology.—(1) *Age:* Between forty and eighty years, average fifty-seven years, rare under thirty. (2) *Sex:* Three times as frequent in men as in women, probably from greater exposure. (3) *Race:* Blond races much more frequently affected than the dark-skinned races; rare in negroes and Indians and in the Latin races. (4) *Exposure* to sun and weather: Farmers (75 per cent.), carpenters, sailors, policemen; frost-bite may favor. (5) *Precancerous dermatoses* usually precede the development of the epithelioma, and include: Seborrheic warts (slowly developing, slightly raised, yellowish or black plaques covered by an adherent greasy scale), senile keratosis, xeroderma pigmentosum.

Site.—Ninety per cent. develop above the level of the upper lip, especially upon the nose, cheeks, outer and inner canthi; less frequently temporal region, forehead, ears, upper lip, dorsal surface of hands, back of neck, back of forearm; the chin and front of neck are rarely involved. *On the nose* the growth elects the alar furrow, nasofacial fold, and the bridge, or the center of the face.

Pathology.—Flat, nodular, ulcerative or annular growths tending to heal at the center and progress at the periphery. Indurated, hard, rolled or heaped-up edges, showing translucent pearly white nodules. Ulcers are covered by pale, unhealthy, thin granulation tissue or yellowish crusts, scabs or dry scales, and exude a yellow serous material. *Morphea-like epithelioma* is irregularly rounded, with a flat, smooth, slightly depressed, whitish-yellow, scleroderma-like central area, surrounded by a ring of raised pearly edged growth. Superficial scabbed ulcerations occur. Telangiectatic vessels, which converge toward the center of the lesion, are common. Multiple growths derived from a common center are not uncommon. Sections show a smooth surface, and limited invasion of subcutaneous tissues by small alveoli. The cells are small, closely packed, with dark, round or elliptical nuclei.

Symptoms.—A chronic lesion with slight itching, burning, irritation, bleeding discharge, or pain. Usual rate of growth, about $\frac{1}{2}$ cm. a year. A relatively benign localized growth, not tending to metastasize or involve adjacent lymphatics, but gradually eroding all tissues, including cartilage and bone; causing death after ten to twenty-five years, from secondary infection, invasion of the meninges or brain, or from hemorrhage. Transformation into the squamous-celled carcinoma occasionally occurs.

Diagnosis.—A slow-growing, hard, painless, bluish-white nodular sore, arising in a previously unhealthy skin-patch on the face of an old man, yielding to radiotherapy. *Squamous-celled carcinoma* grows more rapidly, shows greater induration, more infiltration, more often involves the extremities, genitals, mucocutaneous border of the lips, and regional lymph-nodes. In chancre, the earlier age, the early involvement of lymph-nodes the darkfield examination of the scrapings, and the Wassermann reaction of the blood should clear the diagnosis. With *tertiary lesions* are associated adjacent inflammation, absence of pearly nodules and induration; often the presence of syphilitic scars and other lesions, and a history of infection. *Lupus vulgaris* occurs in young people, the lesions have an irregular outline, with healed atrophic whitish or reddish scars; there is an overhanging ulcer-edge, no induration, and apple-jelly nodules are seen on pressure by a glass slide. *Lupus erythematosus* forms a smooth pink scar, without ulceration or raised indurated edge.

Granuloma pyogenicum, blastomycosis, morphea, and simple inflammatory lesions are, as a rule, readily differentiated. In case of doubt a biopsy should be made.

Treatment.—1. *Prophylaxis:* The eradication of precancerous cutaneous lesions.

2. *Radiotherapy* is effective in early superficial lesions, radium being more conveniently applied and more effective than the Roentgen ray. Advanced growths with involvement of cartilage or bone do not heal from radiation. Unless there is prompt response after two or three treatments, radiation should be abandoned.

The disadvantages are: Chronic radiodermatitis, loss of eyelashes, conjunctivitis, subsequent wrinkling, telangiectasis. Fifteen per cent. relapse in from six months to a year. If there is no recurrence within a year, a cure is probable.

3. *Free sharp knife excision*, effective in over 90 per cent. in the early stage.

NAILS

Anatomy.—Each nail consists of an exposed part or body with a free margin, and a more opaque semilunar area or *lunula* at the base. The *root* of the nail is deeply embedded in a fold of corium (the *nail matrix*), and the lunula is overlapped by a thin epidermic fold (the *eponychium*). Laterally the nail is overlapped by a fold of skin (the *vallum*). The *nail-bed* is the attached corium underlying the body of the nail. After removal, the nail regenerates from both the bed and matrix in about sixteen weeks.

Atrophia unguium (*onychotropia, onychotrophy, atrophy of the nails*) may be congenital or acquired. The nails may be: (1) Thin (*spoon-nails*), being concave from side to side with everted edges; (2) small; (3) loose upon the nail bed (*onycholysis*).

Onychauxis (*overgrowth* or *hyperplasia of nails*) chiefly affects the toe-nails, especially that of the great toe, and occurs in old age and after injury. *Onychogryposis* is a form of overgrown and hooked great toe-nail seen in old people. If troublesome, the thickened nail should be filed thin, or removed, and to prevent recurrence the matrix and bed of the nail should be destroyed by caustic potash stick.

Leukonychia (*the presence of white spots or streaks or bands upon the nails, leukopathia unguium*) may be hereditary or acquired, temporary or permanent, but usually is due to local traumatism and the presence of air in the interstitial corneal spaces.

Transverse ridges or furrows upon the nails mark the periods of constitutional disease with faulty nutrition.

Degeneration of the nails (*onychexallaxis*) includes: Splitting of the nail, *onychorrhexis;* brittle or breaking nails, *onychoclasis;* and abnormal softening of the nails, *onychomalacia.* These conditions may be congenital or acquired, and often depend upon a depraved constitution, or upon a local irritation (chemicals, soaps, Roentgen rays). The **treatment** includes measures to improve the general health and nutrition, and to prevent local irritation. Locally massage with lanolin or other animal unguent is of some value.

Loosening of the Nails (*Onycholysis*).—Periodic or intermittent shedding of nails (*onychomadesis, onychoptosis*) may follow injury, the severe exanthemata, or occur in syphilis, diabetes, or disease of the central nervous system. The **treatment** is constitutional and local, as for degeneration of the nails.

Ingrowing nail (*onychocryptosis*) usually involves the great toe, from shoe pressure, the soft tissues being crowded over the edge of the nail, with ulceration and infection.

Treatment.—Relief of pressure, separation of soft tissues by packing cotton wet with compound tincture of benzoin under the edge of the nail. A wedge-shaped resection of the edge of the nail and adjacent soft tissue is often desirable. While as a rule the nail should be trimmed square across the free margin, it is at times necessary to carefully cut the margins from beneath the inflamed vallum, taking great care not to tear the nail margin and to leave no splinter or rough edge of the nail. For inveterate cases the vallum may be resected, or one-half or the entire nail may be removed, and the bed and matrix destroyed.

Paronychia (*ungual whitlow, run around*), a suppurative inflammation about the margins of the nail, due to infection or ingrown nail, often followed by onychia

and exfoliation of the nail. The eponychium should be gently pushed back and elevated to permit the escape of pus, and hot antiseptic fomentations, or yellow oxid-of-mercury ointment applied.

Onychia (*Onychitis*).—Inflammation of the matrix of the nail, often following a paronychia: (1) *Onychia simplex* occurs with little ulceration, with loss of nail, and replacement. (2) *Onychia maligna* occurs in the debilitated or diabetic, with marked fungous ulceration and exfoliation of the nail. (3) *Tuberculous onychia* and *syphilitic onychia* are rather rare. (4) *Onychia parasitica* (onychomycosis) is usually an infection by ring-worm or favus. The nail becomes opaque, irregular, spongy, ridged or furrowed, and deformed. The treatment is the application of parasiticides containing iodin, fresh sulphurous acid, or mercurials. Avulsion of the nail to permit better access of the parasiticide is, at times, necessary.

Treatment is similar to that for paronychia. Attention should be given the underlying constitutional condition, and pus should early be evacuated by drilling, elevating, or removing the nail.

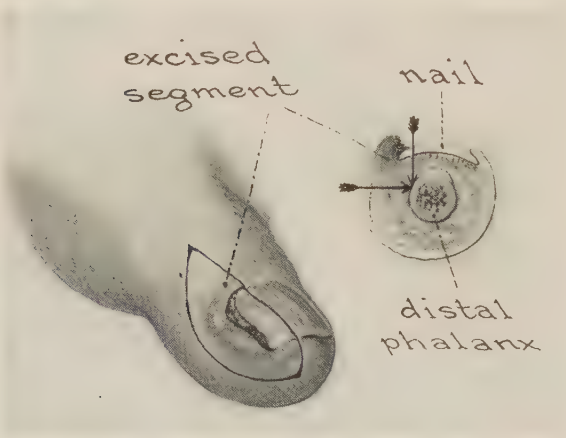


Fig. 324.—Wedge-shaped excision for in-grown toe-nail.

Fig. 325.—Paronychia. Evacuation of pus without cutting by separating the overlying skin from the nail by a thin knife.

Tumors of the Nail-bed (*Onychoma*).—*Subungual callus* or *clavus* may be very painful. It should be destroyed by salicylic acid or other caustic or excised. *Subungual exostosis* is an osteoma growing from the terminal phalanx of the great toe, raising the nail and usually causing an associated ulceration of the skin from pressure. The nail should be raised, and the growth removed by gouge, curet, or chisel.

Malignant disease of nails is rare. Squamous epithelioma and melanotic tumors are the most common.

Melanoblastoma of the nail-bed (*melanotic whitlow*), forms of a deeply pigmented or black, firm, nodular, painful tumor of the nail-bed. The growth may follow injury, and secondary extension occurs through the lymphatics. Death results from metastasis in four to ten years.

Treatment.—Amputation of the affected digit.

CHAPTER XXIII

THE DUCTLESS GLANDS

THYROID

Congenital Anomalies.—The thyroid gland may be deficient in size (hypoplasia), absent (aplasia), or the isthmus or a lobe may be lacking. The pyramidal lobe is present in every third person, and may extend to the hyoid bone. Accessory thyroid glands are not uncommon, and are found at the base of the tongue or attached to the larynx or trachea, and may cause persistent symptoms after removal of the gland proper.

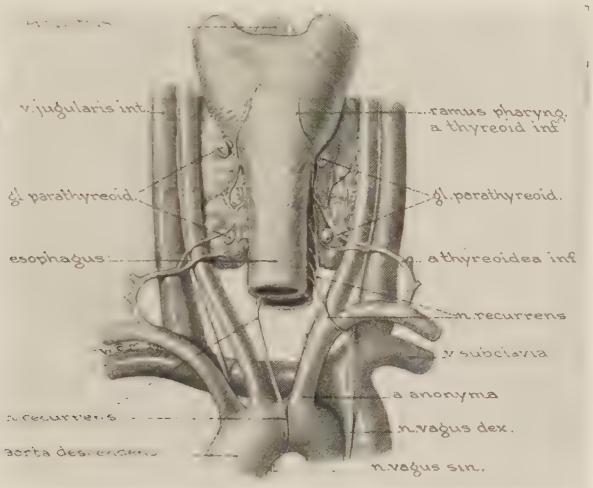


Fig. 326.—Showing the posterior surface and relations of the thyroid gland, with the esophagus, trachea, recurrent nerve, parathyroids, and inferior thyroid arteries.

Thyreoptosis.—Usually the isthmus of the thyroid covers the second, third, and fourth tracheal rings; but the gland may have a lower position, with a considerable proportion lying below the upper border of the sternum (*intrathoracic* or *retrosternal goiter*).

The thyroid is exceedingly vascular and is supplied by four arteries—the *superior* and *inferior thyroids*. The nerve-supply is chiefly through the sympathetic. The gland consists of: (1) A secreting part, the epithelial cells lining the alveoli; (2) a storage part, the colloid substance found in the alveoli. The essential secretion, *thyroxin* (Kendall, 1916), contains 66 per cent. of iodin. Normally the gland should contain 1 per cent. of iodin and, if the percentage falls to $\frac{1}{5}$ of 1 per cent., hyperplasia of the gland occurs.

Physiologic Action.—The internal secretion of the thyroid, *thyroxin*, stimulates nearly every bodily function; in the young it aids growth; in the adult, metabolism.

Thyritis (Thyroiditis).—Inflammation of the thyroid gland is rare.

Etiology.—Thyritis may occur as the complication of: (1) A *general infection*, such as the exanthemata, pyemia, or typhoid. (2) *Contiguous infection*, the inflammation spreading from adjacent structures of the neck. (3) *Trauma*, in which open or closed wounds involving the thyroid are followed by infection.

Symptoms.—The thyroid becomes swollen, red, hot, painful, and occasionally suppurates, with the formation of an abscess.

Treatment consists in the application of cold or evaporating lotions for the first forty-eight hours, if the process is very acute, or yellow oxid-of-mercury ointment for subacute types. After forty-eight hours, if there is suggestion of suppuration, hot antiseptic fomentations should be substituted. If an abscess forms, an early incision after Hilton's method should be made to prevent involvement of the trachea, esophagus, or mediastinum from the spread of the pus. If pressure of the swollen thyroid upon the trachea causes suffocation or asphyxia, a tracheotomy should promptly be done.

Chronic inflammations of the thyroid are unusual and result from tuberculosis or syphilis. *Riedel's disease* or *woody thyroiditis* is a chronic form. The treatment is that of the underlying cause, together with the evacuation of chronic abscesses or, if necessary, the resection or removal of the diseased gland.

Goiter (*struma*, *bronchocele*) is an enlargement of the thyroid not due to inflammation. It may be sporadic or endemic, localized or diffuse, substernal or intrathoracic.

Varieties.—1. *Parenchymatous* or *simple goiter* is a hypertrophic enlargement of the gland, without change in the relative constituents.

2. *Colloid goiter* is a later or resting stage of parenchymatous goiter, characterized by an enlargement of the acini and an excess of colloid, with flattening of the epithelial cells.

3. *Exophthalmic goiter* is characterized by moderate enlargement with marked vascularity, excess of epithelial elements, and relative deficiency in colloid.

4. *Adenomatous goiter* is the growth of masses of new encapsulated tissue in the thyroid, with a structure like that of any of the above forms of goiter, or without colloid, resembling the fetal thyroid (*fetal adenoma*).

5. *Malignant goiter* is due to the development of carcinoma or other malignant tumor in the thyroid.

Any form of goiter may undergo cystic, fibrous, vascular, or calcareous change or hemorrhage; and it should be recognized that cystic, calcareous, fibrous, vascular, or hemorrhagic goiters are not distinct forms of struma.

Etiology.—1. *Physiologic Activity, Age:* The thyroid normally enlarges at puberty, during menstruation, pregnancy, and lactation. Exophthalmic goiter usually develops between the ages of sixteen and thirty; thyroid adenoma, after thirty.

2. *Sex.*—Goiter is nine times as frequent in women as in men.

3. *Iodin deprivation* in relation to *geographical distribution:* The incidence of goiter is inversely as the amount of iodin found in the water and soil of the region. It is endemic in parts of Japan, Asia, England (*Derbyshire neck*), Austria, Switzerland, and the Alps; in the United States, along the Great Lakes, the Hudson River Valley, and parts of the Northwest. The condition is prevented or relieved by iodin feeding.

4. *Season.*—Late winter and early spring—when there is less green vegetable material available as food and, therefore, a lessened intake of iodin—are marked by an increase in goiter.

5. *Contaminated Water, Glacier Water.*—Goiter may be prevented in children living in goitrous regions by filtering or boiling the drinking-water.

6. *Infection.*—The thyroid is stimulated to overactivity by infection of the nasopharynx, gall-bladder, appendix, and by tuberculosis of the lungs and syphilis. In lower animals fecal feeding is followed by the development of goiter.

7. *Nervous Excitation.*—Strain, fear, fright, terror, anxiety, apprehension, etc., may be followed by rapid increase in the size of the thyroid.

Symptoms.—A goiter may cause: (1) *Metabolic symptoms*, from hypothyroidism, hyperthyroidism, or dysthyroidism. (2) *Pressure symptoms*, with (a)

Fig. 327.—Cretinism with hypoplasia of thyroid (After Berry.)

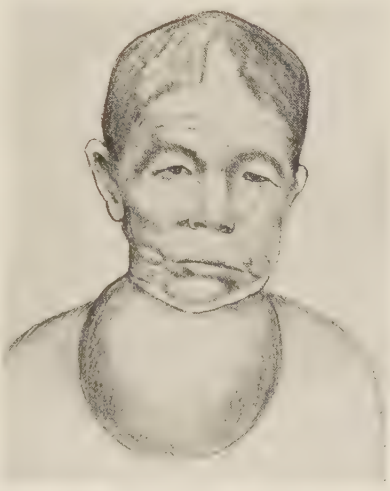


Fig. 328.—Cretin with large cystic goiter. (After V. Eiselsberg.)

Tracheal congestion, or displacement, narrowing (*scabbard trachea*), softening or collapse; leading to tracheal catarrh, dyspnea, or apnea; (b) *recurrent nerve-paralysis* or irritation, with laryngeal spasm, hoarseness, and cough; or (3) *esophageal pressure* with dysphagia.

Treatment of goiter varies with the variety.

Hypothyroidism is the condition of insufficient thyroid activity. At puberty, two-thirds; at thirty years, four-fifths; at forty years, nine-tenths of the normal thyroid may be removed without causing hypothyroidism. Hypothyroidism may be congenital, acquired, or the result of operative removal of the thyroid.

Varieties.—1. *Congenital* or *preadolescent* (*cretinism*)—from aplasia, hypoplasia, cystic goiter, degenerated goiter.

2. *Acquired* or *postadolescent* (*myxedema*)—from atrophy after inflammation, or hyperplasia, hypoplasia, colloid or cystic goiter.

3. *Postoperative* (*cachexia strumipriva*)—from removal of an excess of thyroid substance.

Congenital or **preadolescent hypothyroidism** (**cretinism**) is characterized by stunted growth, both physical and mental. This may vary in intensity, and when extreme, results in an obese, bow-legged, pot-bellied, idiotic dwarf.

Etiology.—Cretins are more common in goitrous regions, the offsprings of parents with thyroid disease. The thyroid may be small and hypoplastic, or large (goiter) with insufficient function of the epithelial cells.

Symptoms.—1. *Development Delayed:* Shown in late walking, talking, eruption of teeth, and lack of growth. 2. *Mental Deficiency:* Dulness, physical and mental inertia, open mouth, myopia, imbecility. 3. *Skeletal System:* Bones small, stunted, deformed; fingers thick and club-like. 4. *Skin* is thick, infiltrated, rough and dry, the lips and tongue thick; hair scanty, falling, brittle, thinning at lateral curves of eyebrows. Teeth poorly formed and irregular. 5. *Circulatory System:* Brachycardia, low blood-pressure. 6. *Digestive System:* Constipation. 7. *Metabolism* reduced, increased carbohydrate tolerance. Obesity, lowered temperature. 8. *Sexual System:* Lowered activity and amenorrhea.

Cretinism is improved by thyroid feeding or after thyroid implantation.

Postadolescent Myxedema.—The patient is dull, forgetful, apathetic, and somnolent; the special senses show decreased activity; the skin is rough and dry; the hair becomes dry and brittle and falls out; there is thinning of the lateral part of the eyebrows, and puffiness of the skin of the face, particularly about the eyes. There is a depression of the heart action and metabolism, and a slowing of all the normal functions. The condition may progress to coma and death, especially in young adults. The thyroid gland may be large, with advanced cystic or colloid change, and degeneration of the epithelial elements; or may be small and atrophic. A previously hyperactive or inflamed gland may undergo degeneration or cystic change, with secondary myxedema.

Postoperative myxedema (*cachexia strumipriva* or *thyropriva*) occurs from total thyroidectomy or a too extensive partial thyroidectomy and resembles the postadolescent form. The removal of the entire thyroid after middle life is less often followed by symptoms than in earlier life.

Treatment.—(1) Feeding with thyroid gland or thyroxin. (2) Glandular implantation. Portions of thyroid tissue removed from other animals and transplanted to man (*heterologous transplantation*) promptly degenerate. *Homologous implantation*, where the transplant is made of a portion of gland from another human being, is also followed by atrophy and degeneration, although not to the same degree. The best results have been obtained from transplantation into the bone-marrow or spleen. On account of the difficulty, danger, and transient effect of these operations, thyroid feeding has largely supplanted thyroid implantation.

Dysthyroidism (**Thyrotoxicosis, Toxic Secretion**).—Characterized by a perverted thyroid secretion; this apparently occurs in exophthalmic goiter, as the symptoms are not the same as those produced by thyroxin or thyroid feeding.

Hyperthyroidism (*excess of normal thyroid secretion*) is found in: (1) *Parenchymatous goiter*, and normally with the acceleration of puberty, menstruation, pregnancy, and lactation. (2) *Toxic adenoma.*

Hyperthyroidism results from an excessive absorption of the thyroid secretion (*thyroxin*) and is characterized by the stimulation of nearly every bodily function. In toxic adenoma of the thyroid, the symptoms are identical with those produced by administering thyroid or thyroxin.

Pathology.—There is a decrease in colloid, and an increase in epithelial elements and nitrogen of the thyroid. The acini are small, the lining epithelium hyperplastic, and an excess of thyroxin is formed.

Symptoms.—*Nervous System:* Restlessness, anxiety, irritability, tendency to emotional upset, hot flushes, insomnia, fine fixation tremor.

Skin: Soft, white, moist, occasionally pigmented; hyperhidrosis, especially of hands and axillæ. Hair soft, luxuriant, of fine texture and luster.

Skeleton: Small bones, tapering thin fingers.

Digestive Tract: Vomiting, diarrhea, hyperacidity; teeth well formed, appetite usually good.

Circulatory and Respiratory Tracts: Tachycardia; secondary fibrillation and incompetency.

Muscular System: Weakness of voluntary muscles, especially noted in quadriceps femoris on ascending stairs.

Metabolism: Greatly increased, lowered carbohydrate tolerance, wasting despite increased food intake.

Tests are of limited value, and include: (1) Alimentary glycosuria. (2) Adrenalin test (Goetsch). (3) Loewi's reaction. (4) Achner's phenomenon—pulse is reduced by pressure on the eyeball. (5) Pilocarpin reaction—decreased carbohydrate tolerance, even after adrenalin. Hyperhidrosis, clammy extremities, low blood-pressure (vagotonic symptoms), possibly indicate thymus influence or lack of adrenalin.

Treatment.—Inhibition or removal of hyperplastic portions of the thyroid, as discussed later.

Simple parenchymatous goiter (*simple struma* or *bronchocele*) is a uniform enlargement of the thyroid gland, which normally occurs during puberty, adolescence, or pregnancy. As a rule, both lobes are enlarged symmetrically, although one may be larger than the other. There is no marked toxicity and, apart from a slight nervous hyperesthesia, no general symptoms.

Treatment consists in: (1) *Iodin feeding:* Ten milligrams of iodin is given weekly for thirty weeks of the year; or 2 gm. of sodium iodid, twice yearly; or 3 to 5 mg. of iodin, twice weekly for a month, twice yearly. Iodin should not be used after the age of twenty-one. (2) The *elimination of sources of infection*, that may aggravate the thyroid, such as infected tonsils, adenoids, chronic rhinitis or sinusitis, and the like. (3) *Radiation* by radium or *x*-ray is not usually required. (4) *Operation* is not indicated for simple parenchymatous goiter unless the condition has progressed into marked colloid or cystic change, or produces objectionable disfigurement or serious pressure symptoms.

Exophthalmic Goiter (*Flajani's Disease*, 1802; *Parry's Disease*, 1825; *Graves' Disease*, 1835; *Basedow's Disease*, 1840).—A thyrotoxicosis or dysthy-

roidism, having as its cardinal symptoms: (1) Goiter; (2) exophthalmos; (3) tachycardia; (4) tremor, and weakness of the voluntary muscles, particularly the quadriceps extensor group; (5) metabolic hyperactivity, and (6) digestive disturbance.

Pathology.—The gland is firm and vascular, with an excess of nitrogen and epithelial cells, and a deficiency in colloid. The alveoli are small, the lining cells in such excess that the basement membrane often is thrown into folds or ridges.

Etiology.—Graves' disease usually occurs in young women, and is most frequently noticed about the age of twenty-six. It usually appears without previous evidence of thyroid enlargement, and possibly in patients who have had an insufficient amount of iodin in the food. The condition may be precipitated by extreme emotion, such as fright, terror, or great mental strain. It is relatively more common in non-goitrous communities.

Symptoms.—1. The *goiter* is rarely large, but is elastic, rather dense, firm, granular, pulsatile, often having a thrill or murmur. It rarely produces pressure

Fig. 329.—Parenchymatous goiter.

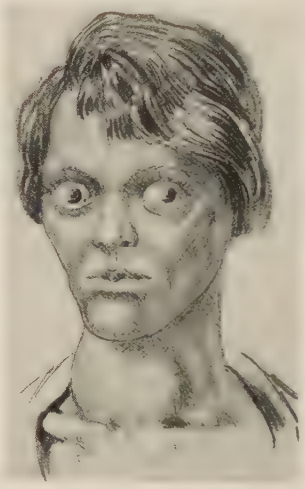


Fig. 330.—Exophthalmic goiter.

symptoms, and often is not noticed until after the staring eyes, the tachycardia, and the nervousness have attracted attention.

2. *Ocular Symptoms.*—These include: (a) *Exophthalmos*—the protruding eyeballs are caused by an increase of orbital fat and spasm of the orbital muscle of Müller; (b) *lagging of the upper lid* when the patient looks down (*von Graefe's sign*); (c) *widening of the palpebral orifice* (*Stellwag's sign*); (d) *failure of the frontalis* to contract and wrinkle the forehead as the patient looks up (*Joffroy's sign*); (e) *infrequent winking* causing a fixed stare (*Dalrymple's sign*); (f) lack of convergence for near objects, without diplopia (*Möbius' sign*).

3. *Circulatory Symptoms.*—Tachycardia in which the heart-rate is from 80 to 200 beats per minute. A cardiac murmur, usually systolic, is not infrequent, best heard at the base or the second left interspace. *Auricular fibrillation* is common, and death may occur from vasomotor paralysis with widening of

the peripheral vascular fields, and a sharp drop in the diastolic blood-pressure producing a condition similar to that seen in shock. The excessive work of the heart may be followed by cardiac dilatation, secondary edema of the legs, and other signs of decompensation. The blood-pressure is variable, but usually moderately increased, and visible pulsation of the vessels in the neck is common.

4. *Mental* and *nervous symptoms* include: Mental excitability, instability, insomnia, restlessness, fixation tremor (best seen in the fingers), and choking sensation; and in extreme and usually fatal cases, delirium and acute mania. Stimulation of the sympathetic system is shown by flushing and marked sweating.

5. *Metabolic rate* is increased from +15 to +100 or more, with increased temperature and sense of oppressive heat, and wasting and emaciation despite an increased intake of food. The skin may show areas of pigmentation, with dermographia, flushing, sudorrhea. Anemia and amenorrhea are not uncommon. The blood may show a leukocytosis and mononucleosis. Albuminuria or glycosuria occasionally occur.

6. *Digestive Symptoms.*—The appetite is usually good and the food intake large, wasting occurring from excessive combustion. In extreme cases there is diarrhea and vomiting.

Prognosis.—The disease tends to progress in waves, with periods of marked exacerbation and remission, marked emaciation, and finally cardiac insufficiency. The mortality is about 25 per cent. without operation. Improvement for from six weeks to three months often follows ligation of one or more thyroid arteries, the application of Roentgen rays or radium, iodin feeding, or the injection of boiling water or quinin and urea solution into the gland. The results from these various forms of treatment are not, as a rule, permanent. The *operative mortality* is 25 per cent. if no special precautions are taken before or during the operation; or 1 or 2 per cent. where the patient is carefully prepared, and the operation skilfully performed. The operation is dangerous if done while there is delirium or mania, diarrhea or vomiting, evidence of cardiac decompensation, a pulse over 120, a metabolic rate above +50, or if the patient has had a recent rapid loss of weight. A persistent thymus may be responsible for restlessness and excitement, collapse, suffocation, or attacks of angina after operation.

Treatment.—The successful treatment of exophthalmic goiter is by operation. The metabolic rate does not give an accurate criterion as to the danger of the operation. To reduce the danger of operation, preoperative study and treatment are necessary:

1. *Complete mental* and *physical rest* in bed, a high-caloric diet, with a reduction in protein and fat. Meat, eggs, milk, and coffee are withheld.

2. *Digitalization*, to rest and strengthen the heart, is less important than general rest.

3. *Iodin feeding* (Plummer) is the most valuable single preoperative measure. It eliminates the necessity of preliminary-stage operation in over 80 per cent. of the patients. Ten to fifteen drops of Lugol's solution are given three times a day for from ten days to three weeks before the operation, dependent upon the patient's condition and the effect produced. If a crisis threatens, a single dose of 50 minims is given by mouth or rectum, or the intravenous injection of 2 gm. of

sodium iodid in 20 c.c. of distilled water. The iodin treatment should not be long continued and is of chief value as an immediate preoperative treatment.

4. *Removal of associated septic foci*, such as tonsils, adenoids, and the like, is often desirable.

If the patient is in serious condition the "step" method of treatment enables one to reduce the mortality to 1 per cent. or less. The patient is treated by rest, diet, overfeeding, iodin, followed by radiation, injections, ligation, either alone or in sequence, until the tachycardia is relieved, the weight increased, and the metabolic rate reduced. The gland is then exposed by operation and, if the patient continues in good condition on the operating table, a bilateral partial lobectomy with removal of about four-fifths to five-sixths of the gland made. If alarming symptoms develop under the operation, the gland is gently surrounded by gauze packs, and the operation completed one, two, or three days later.

Profound general anesthesia is dangerous. The operation should be done largely under local anesthesia, aided by a light analgesia produced by nitrous acid-oxygen or ethylene. *Anoci-association*, or Crile's method, has been described as the stealing of the gland without the patient's knowledge. The patient enters the hospital, but is not told when the operation is to be done; daily hypodermic injections, daily inhalations of air and, perhaps, a little nitrous oxid from a gas-oxygen machine, and the wearing of a bandage about the neck are continued until they no longer excite the patient; then, on a day selected without the patient's knowledge, a hypodermic of morphin is substituted for the previous injections of salt solution, nitrous oxid is given to analgesia, a local anesthetic injected to block the peripheral nerves, and the gland is removed, preferably in the patient's own room. With certain patients the suspense and delay of the method produce more excitation than would a candid announcement of the plan of treatment and the day of operation.

Thyroid Crisis.—A crisis is a marked exacerbation in the thyrotoxic symptoms, and may occur during a period of exacerbation, after a fright or mental excitation, after radiation or the injection of adrenalin, and especially after a surgical operation. A crisis is more apt to follow an operation if the patient is under twenty-five years of age, has recently been losing weight, has a high metabolic rate, is in a period of exacerbation, and has not been carefully prepared. If the operation is done during the period of excitation, delirium, mania, diarrhea and vomiting, or with tachycardia above 120; if deep anesthesia, especially by ether, is used; if the operation is prolonged, hemorrhagic, or attended by much trauma, and if the patient is given adrenalin, a crisis is precipitated. The condition is characterized by great mental excitation tending to pass into delirium, mania, and coma, with great restlessness, marked tremor, increasing tachycardia, and death from exhaustion, usually on the evening of the second day after operation. The pulse rate varies from 150 to 200, the rectal temperature may reach 107° F. or more, and the condition in many respects resembles that of sun-stroke.

Treatment is active refrigeration by iced sponges and ice-caps to the head, cold enemas, iced-water lavage of the stomach, and, in extreme cases, the patient may be placed in a tub of cold water and massaged with ice until the rectal temperature falls to 101° F. Iodids should be given by mouth, rectum, and intravenously. Dehydration is combated by salt solution subcutaneously and by

bowel, and glucose in normal saline solution given intravenously. Morphin is used by certain operators to full narcosis.

Adenoma of the thyroid may be single or multiple, localized or diffuse. According to structure, adenomas are divided into: (1) *Fetal adenoma*, which are without colloid or acini, and have the structure of the fetal gland. (2) *Colloid adenoma*, having the structure of a colloid goiter. (3) *Intermediate*, and (4) *mixed types.*

Usually adenomata are localized, encapsulated, globular, and of the colloid type. Adenomata frequently undergo cystic change from hemorrhage, degeneration, or colloid deposits. The not infrequent intrathoracic adenoma often is overlooked. Adenoma of the thyroid is usually first noticed after the age of thirty, forming a nodular bosselated enlargement of the gland, with an elastic tenseness greater than that of the adjoining gland. Hemorrhages may cause

Fig. 331.—Adenomatous goiter.

Fig. 332.—Multiple cystic adenoma of the thyroid gland.

a sudden increase in size. Compression of the trachea, or pressure upon the recurrent nerves, with dyspnea or dysphonia, occurs more frequently than from simple or exophthalmic goiter. Usually, however, no symptoms except the lump in the neck are noticed until, after an average duration of sixteen years and at an average age of forty-four (Plummer), hyperthyroidism or cardiac symptoms attract attention.

Toxic Adenoma: Toxic symptoms are not invariable, and are precipitated by the administration of iodin. In the toxic adenoma there is tachycardia, loss of weight, high basal metabolic rate, nervousness, mental instability, muscular weakness, especially of the quadriceps group, tremor, sweating, diarrhea, at times vomiting, myocardial insufficiency, and a tendency to thyrotoxic crisis.

Prognosis.—Adenoma of the thyroid gland is persistent, not amenable to radiation or medication, and, as far as known, the condition is to be surely

relieved only by surgical removal. Primary carcinoma of the thyroid develops from a pre-existing adenoma.

Treatment.—For the cosmetic effect, to avoid or relieve thyrotoxicosis and pressure symptoms, and to prevent the development of cancer, adenomas should be enucleated with or without the adjacent portion of the thyroid. For non-toxic adenomas the mortality is $\frac{1}{10}$ of 1 per cent. For toxic adenomas preliminary ligation is of little value, except to test the patient's reaction to operation. The patient is prepared for operation by rest, digitalization, a diet with reduced proteins and fat, and, at times, the injection of boiling water or quinin and urea into the adenoma. Iodin should only be used immediately before or after operation, and under very careful supervision. Operation is dangerous without careful preparatory treatment, if the patient has recently lost much weight, if there is a high metabolic curve, if the tachycardia is extreme, if the patient borders on mania, or if there is myocardial insufficiency or auricular clot.

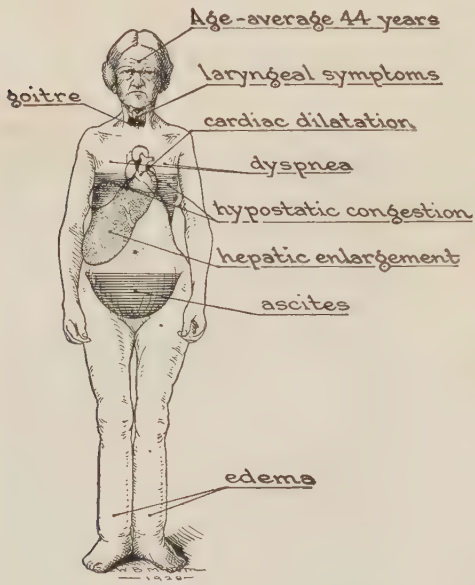


Fig. 333.—Congestive heart failure from toxic adenoma of the thyroid.

Heart Disease and Toxic Adenoma.—Congestive heart failure in middle life is often due to an overlooked or unsuspected adenoma of the thyroid. The condition frequently occurs in men, and is to be suspected if there is a history of one or more previous attacks of transient decompensation. The adenoma is often small, inconspicuous, or intrathoracic; there is enlargement of the liver, edema of the extremities, dulness at the base of the lungs, with cough. Lahey has shown that, when these patients are relieved of the toxic burden from the adenoma, a relative recovery often follows.

Displacement of auricular clot, with sudden death from cerebral embolism, is the great danger in these patients, and operation should not be attempted until the patient has been at absolute rest in bed for at least three weeks, for fixation of auricular thrombi. The operation should not be prolonged or very traumatic. Ether and other lipoid-solving anesthetics are to be avoided. Local anesthesia, conjoined with a light ethylene analgesia, is preferred.

Malignant Tumors of the Thyroid Gland.—A. **Carcinoma** constitutes about 80 per cent. of the malignant tumors of the thyroid, and originates in a pre-existing adenoma, which may have been overlooked because of intrathoracic position.

Varieties.—(1) *Malignant adenoma* is the most common type (80 per cent.). (2) *Primary adenocarcinoma* usually grows from the walls of an adenomatous

cyst, produces local invasion without distant metastasis, and is only slightly malignant. (3) *Scirrhous carcinoma* resembles that found in the mammary gland; is rare, tends to invade the trachea, larynx, esophagus, lymph-nodes, and may be confused with a chronic thyroiditis. This form usually is fatal in from twelve to eighteen months, and rarely has been recognized before local invasion has rendered complete operative removal impossible.

Symptoms are enlargement and discomfort referred to a pre-existing adenoma, usually in a woman past middle life, with a tendency to fixation and involvement of adjacent structures, such as the trachea, skin, larynx, esophagus, and lymph-nodes. The involvement of the recurrent nerve is followed by hoarseness and cough. Mydriasis or myosis, unilateral sweating and flushing of the face are due the involvement of the cervical sympathetic.

Prognosis of the primary adenocarcinoma is good, of the malignant adenoma only fair, and of the scirrhus carcinoma of the thyroid very bad.

Fig. 334.—The thyroid gland with its anterior anatomic relations and the line of incision for thyroidectomy.

Diagnosis.—Carcinoma of the thyroid is difficult to diagnose in the early stage, and later may be confused with carcinoma of the cervical esophagus. Enlargement with pain in an adenoma of the thyroid after the age of forty indicates operation, without waiting for the other evidence of malignancy. Complete extirpation is feasible only before invasion of the important adjacent structures has occurred. Often the diagnosis is not made during the stage that surgical removal is possible. Palliation and prolongation of life may be obtained by the use of radium and Roentgen rays.

B. **Sarcoma** of the thyroid is one-fifth as frequent as carcinoma, and should be treated by extirpation or radiation.

Operations on the Thyroid.—The preferred general anesthetic is ethylene or nitrous oxid-oxygen; the preferred local anesthetic is procain. In toxic

patients operations should be brief; traumatism from pressure, handling or squeezing of the tissues should be minimal.

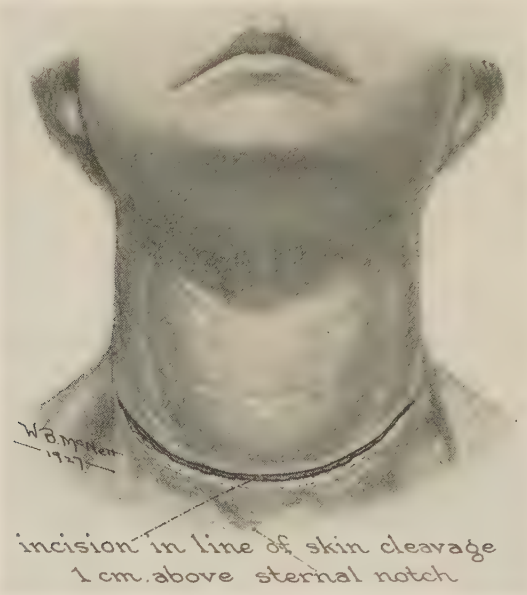


Fig. 335.—Low collar incision for operation upon the thyroid. When the head is extended the incision is raised 1 cm. or more.

Injection.—The skin is first infiltrated with a 1 per cent. solution of procain. A fine needle is introduced into the prominent part of the gland or adenoma, from a point on the mesial edge of the sternomastoid. Movement of the needle by

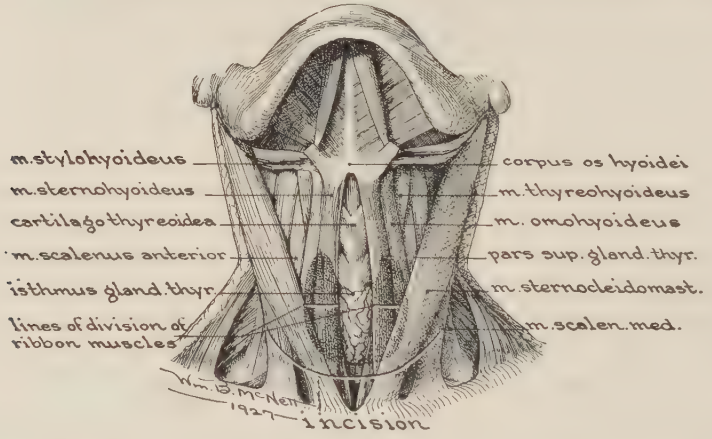


Fig. 336.—Thyroid gland, lines of skin and muscular incisions, and relationship of the gland to the muscles of the anterior part of the neck.

swallowing proves that the needle is in the gland; aspiration, that the needle-point is not in a blood-vessel. Having made sure that the needle-point is in the thyroid, not near the trachea or posterior capsule (recurrent nerve, parathy-

roids), or in a blood-vessel, the injection is started. If the amount injected is large, the needle-point may be cautiously moved to better distribute the solution. The injection may consist of 2 to 5 c.c. of boiling water (Porter), ½ to 2 c.c. of 95 per cent. or absolute alcohol, or 1 to 2 c.c. of a 30 to 50 per cent. solution of quinin and urea (Watson). All produce the desired necrosis, the quinin solution being safest and also the least destructive. The injections may be repeated every four to ten days. At times a single injection will be followed by remarkable improvement in toxic symptoms, but frequently it is difficult to destroy sufficient of the gland by the injections to give decided relief, unless the gland first be exposed by incision. In severe thyrotoxicosis the mortality of boiling-water injections is about 2 per cent.

Ligation.—The superior pole is preferred. *Incision* is transverse, about 2 cm. long, extending inward from the mesial edge of the sternomastoid opposite the cricoid; using small narrow retractors, the superficial and deep fascia are divided, and the superior pole exposed and ligated with fine silk or linen in a small full curved needle (Crile). The ends are cut short and the skin closed.

Thyroidectomy.—*Bilateral partial lobectomy. Incision:* A transverse, low collar incision, 7 to 12 cm. long, is used following the line of a normal wrinkle fold or, in women, placed where the scar will be covered by a narrow necklace or lavalier. The skin is dissected upward from the platysma, which is divided transversely at a higher level. For small glands or adenomas, the ribbon muscles are separated in the midline; for larger or toxic goiters, the ribbon muscles are divided transversely, between light clamps. Beginning above, and catching every bleeding part, the isthmus is divided, and one lobe gradually rolled out and delivered as the incision is made, leaving a thin layer of gland with the posterior capsule to protect the recurrent nerve and parathyroids. The superior pole, the lateral veins, and the inferior pole are successively clamped and divided, and the portion of lobe removed. The opposite lobe is resected in a similar manner, all vessels carefully ligated, the patient being encouraged, at this time, to strain or cough to demonstrate vessels imperfectly occluded. The wound is then accurately closed in layers. If there is no oozing, drainage is not required.

Fig. 337.—Farr's sharp-pointed spring retractor.

Two-stage Operation.—At the first operation, the operation is terminated according to the condition of the patient, after: (1) Exposure of the thyroid; (2) exposure and injection of the thyroid; (3) exposure and polar ligation, or (4) single partial lobectomy.

The wound is packed with gauze and left open, the operation being completed twenty-four to forty-eight hours later. In the very toxic patient, this is much safer than a single-stage operation. If the patient develops shock, or a pulse rate above 140, the operation should be terminated.

Postoperative treatment includes: (1) Comfortable supporting bandage for the neck and head. (2) Complete rest in the Fowler position. (3) Transfusion for extreme weakness or acute anemia. (4) Liquids by mouth, hypodermoclysis, or proctoclysis for dehydration. (5) Heat for shock. (6) Refrigeration

for toxic crisis. (7) Digitalis or quinidin for auricular flutter or fibrillation. Fibrillation should soon disappear if sufficient amount of thyroid has been removed. (8) Iodin and quinin hydrobromid for thyrotoxicosis. (9) Calcium lactate and parathyroid for tetany. (10) Morphin (with care) for sedation.

Hemithyroidectomy or single lobectomy should only be used as a stage operation. The remaining lobe may enlarge, and the disfigurement and symptoms be greater than before operation.

Operation in thyrotoxicosis fails to cure when insufficient amount of gland tissue (less than four-fifths or five-sixths of the entire gland) is removed, or when there is a residual cardiovascular disease or neurosis.

Operative Complications.—1. *Primary Hemorrhage:* Serious loss of blood during operation should be treated by subcutaneous infusion, or by transfusion of blood.

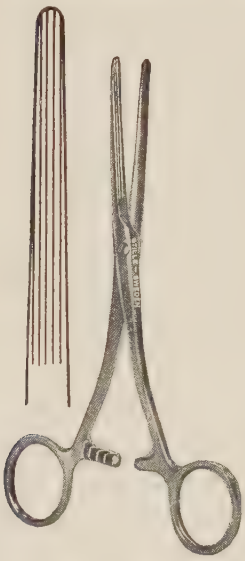


Fig. 338.—Crile thyroid muscle clamp.

2. *Secondary hemorrhage*, caused by the slipping of a ligature or the opening of a vessel from the strain of coughing or vomiting, causes a slow asphyxia from the compression of the trachea, with inspiratory dyspnea, stupor, coma, and finally death unless the pressure is relieved.

Treatment consists in immediately opening the incision, the evacuation of blood, artificial respiration if necessary, and the prevention of further bleeding by ligation or packing.

3. *Tracheal Collapse:* A distorted, scabbard-shaped, softened or displaced trachea may collapse before, during, or after removal of the thyroid, producing suffocation. The *treatment* is an immediate tracheotomy; a long tracheal tube may be necessary.

4. *Accessory nerve injury* occurs from the pressure of an adenoma, postoperative edema, scar-tissue formation, the invasion of carcinoma, the cutting of the nerve during operation, or its inclusion by a ligature. If a single nerve is divided or paralyzed, there is hoarseness and dysphonia. The laryngoscope shows the affected vocal cords in the paralyzed or in the cadaveric position. In a lobectomy, by retaining the posterior capsule of the thyroid (Mayo), or better, by leaving a layer of the posterior mesial surface of the gland, the nerve which runs in the groove between the esophagus and trachea is protected. Deep mass-ligatures and the blind grasping for bleeding points in the depths of the wound should be avoided. Division of both recurrent nerves is followed by severe dyspnea and suffocation, requiring tracheotomy.

5. *Air embolism* occurs through openings in the large veins of the neck, and may be fatal. All large veins should be clamped before division, and carefully ligated. With an open vein the wound should be kept flooded with saline solution, or the cardiac end of the vein occluded by packing the inferior part of the wound with wet gauze sponges.

6. *Parathyroid Injury:* These minute reddish glands, four to six in number, lie behind the posterior capsule, and are supplied by individual arterial branches.

They should be protected by not removing the posterior capsule of the thyroid gland or by leaving a layer of the posterior part of the gland, and by preserving their blood-supply. Tetany results from the removal of parathyroids, the patient first noting a muscular stiffness which is later followed by the peculiar tetanic spasms. This complication is rare and, usually, is not fatal.

The *treatment* is the intravenous administration of calcium lactate; the removal of decomposing proteins from the alimentary tract; and the subcutaneous injection of the parathyroid hormone of Collip.

Auricular fibrillation is to be treated by complete rest, digitalization, or the use of quinidin.

THYMUS

Size.—From a normal weight of about 7 gm. at birth, the thymus enlarges until it reaches about 10 gm. at two years of age, after which progressive atrophy, more rapid after puberty, sets in. From pathologic enlargement the thymus may weigh up to 70 gm.

Fig. 339.—Asphyxia in hyperplasia of the thymus. Sinking in of anterior neck region. Contraction of auxiliary muscles of respiration. Drawing in of lower thorax on inspiration. (After H. Klose.)

Enlargement of the thymus occurs in status lymphaticus, Graves' disease, Addison's disease, myasthenia gravis, infectious leukemia, and other conditions associated with lymphatic enlargement. The enlarged thymus shows little change in histology from the normal gland.

Symptoms.—The enlarged gland presses upon the trachea, and produces: (1) *Laryngeal stridor*, characterized by noisy, obstructed breathing, hoarse cough, attacks of syncope, restlessness, and sleeplessness; noted at birth, or soon after. (2) *Thymic asthma (Pott's asthma)*, or laryngeal spasms, which are severe, suffocative asthmatic attacks, occurring in young children, and may be fatal. (3) *Status lymphaticus, status thymicolymphaticus:* Affects infants and

young children, who usually are pale, flabby, and rather fat, and have enlarged thymus, tonsils, adenoids, and lymph-nodes, particularly those in the abdomen. The spleen and adenoid tissue of the intestine may also be hyperplastic. Attacks of asphyxia may develop, and *thymic death* occur during sleep, the administration of an anesthetic, or from a trivial cause. The enlarged thymus is best shown on the roentgenogram.

Treatment.—(1) *Prophylaxis:* Roentgen-ray examination of the thymus before the administration of a general anesthetic to a baby or child. The thymus is rapidly reduced in size by Roentgen-ray treatment. (2) *Thymectomy* is rarely required.

Roentgen-ray radiation gives relief in 96 per cent. of the cases, with recurrence in 22 per cent.

HYPOPHYSIS CEREBRI

Anatomy.—The hypophysis (pituitary body) occupies the hypophyseal fossa (sella turcica), being attached to the base of the brain behind the optic chiasm by the infundibulum. It weighs about $\frac{1}{2}$ gm., and has a transverse diameter of 12 to 15 mm., and a vertical and anteroposterior diameter of from 5 to 8 mm. It consists of an anterior lobe (*pars anterior*), a posterior lobe (*pars tuberalis* or *nervosa*), and a middle lobe (*pars intermedia*).

A. **Anterior lobe** forms two-thirds of the pituitary, and partially envelops the posterior lobe. It is derived from Rathke's pouch, an outgrowth from the primitive buccal cavity or stomadæum, and is composed of columns of epithelial cells with numerous blood-sinuses and vessels. It is apparently not essential to life (Camus and Roussy). Partial removal is followed by infantalism, with deficient development of secondary sexual characteristics.

The *secretion* influences: (1) The growth of the skeleton, skin, and soft tissues. (2) The sexual organs. (3) Calcium and magnesium metabolism. (4) Carbohydrate metabolism. (5) Basal metabolic rate.

Hyposecretion (*anterior-lobe hypopituitarism*) before puberty is followed by *infantilism type Lorain.*

Hypersecretion (*anterior-lobe hyperpituitarism*) from hyperplasia or neoplasm (1) before puberty causes *gigantism*, (2) after puberty, *acromegaly.*

B. **Posterior Lobe.**—The pars nervosa and infundibulum develop from a down-growth of the cerebral vesicle, the thalamencephalon. The infundibulum is hollow, and in certain animals connects with the third ventricle. The posterior lobe—rather avascular and made up chiefly of neuroglia without true nerve-cells or fibers—has an internal secretion, *pituitrin.*

Pituitrin.—1. Stimulates unstriped muscle of: (a) Blood-vessels—raises blood-pressure. (b) Uterus—powerful oxytocic. (c) Intestine—relieves intestinal atony and tympany. (d) Bladder—increases expulsive power. (e) Mammary gland—a transient galactagogue. (f) Kidneys—diminishes excretion of urine.

2. Lowers carbohydrate tolerance, may cause hyperglycemia and glycosuria.

3. Increases metabolism.

4. It is antagonistic to insulin.

C. **Pars intermedia,** also derived from Rathke's pouch, forms the pos-

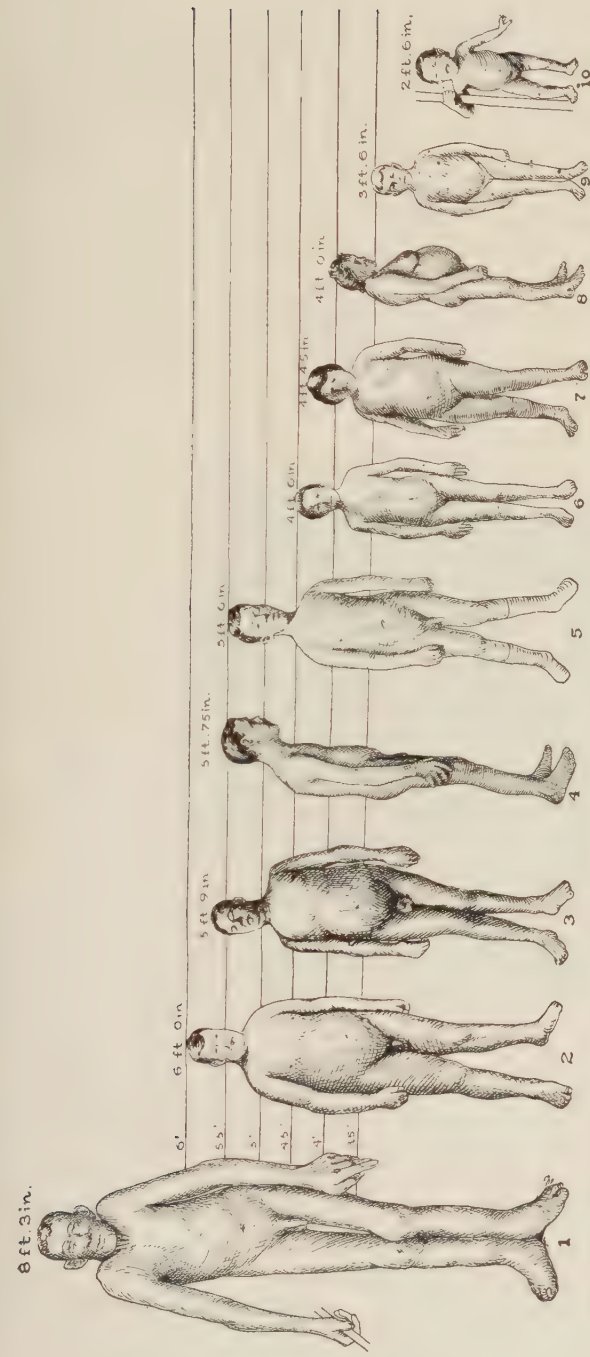


Fig. 340.—Clinical examples of glandular dysfunction. 1, Gigantism from preadolescent hyperpituitarism from cystic struma of pituitary. Aged thirty-six, height 8 feet 3 inches, weight 275 pounds. Hypotrichosis, hypoplasia sexualis, enormous overgrowth of hands and feet, hypophyseal (?) headaches and epistaxis, asthenia (Cushing). 2, Dyspituitarism with overgrowth, adiposity, vertigo, convulsions, hypotrichosis, high carbohydrate tolerance, sexual hypoplasia. Aged sixteen, weight 275 pounds (Cushing). 3, Pituitary hibernation (hypersomnia) adiposity, temporal hemianopsia, blindness, Cheyne-Stokes respiration from large infundibular tumor. Aged forty-one, height 5 feet 6 inches, headache, disorientation, hypotrichosis, large suprasternal and supraclavicular pads, asthenia (Cushing). 4, Acromegaly followed by dyspituitarism, associated substernal goiter. Aged fifty-nine (Cushing). 5, Polyglandular syndrome, precocious sexual adolescence, overgrowth, adiposity, hypertrichosis, asthenia, and optic atrophy suggesting pineal, hypophyseal, and testicular dysfunction. Aged eight (Cushing). 6, Infantilism, type Lorain. Hypopituitarism with an enlarged deformed sella. Aged twenty years six months; height 4 feet 4 inches (after Ettore Levi). 7, Posttraumatic hypopituitarism with adiposity, high sugar tolerance and epilepsy. Aged ten (Cushing). 8, Polyglandular syndrome, painful obesity, temporal headaches, hypertrichosis, amenorrhea, overdeveloped secondary sexual characteristics, low-grade hydrocephalus, increased cerebral tension. Possible pituitary-adrenal-pineal ovarian dysfunction. Aged twenty-three (Cushing). 9, Infantilism, sexual hypoplasia, hypotrichosis. Aged twenty-nine. 10, Cretinism, eighteen-year-old girl (after Kraus-Brugsch).

terior wall of the intraglandular cleft between the anterior and posterior lobes, and consists of polygonal neutrophil cells, hyaline bodies, and colloid without iodin and with but few blood-vessels.

Apparently it has an action like that of the pars nervosa, but is less powerful.

Hypopituitarism, Posterior-lobe Type: 1. **Before adolescence** appears to be characterized by the *Fröhlich syndrome (dystrophia adiposogenitalis)*, with: (a) *Obesity* and overgrowth. (b) *Increased sugar-tolerance* (150 gm. of sugar cause no glycosuria). (c) *Sexual hypoplasia.* (d) *Excessive appetite.* (e) *No mental impairment.*

2. **After Adolescence:** (a) *Obesity*—girdle and mammary type. (b) *Somnolence, torpidity* (pituitary somnolence, pituitary hibernation), patient may have great difficulty in keeping awake. (c) *Increased basal metabolism.* (d) *Increased carbohydrate tolerance.*

Pathologic and Compensatory Changes.—The pituitary enlarges in pregnancy and after castration (eunuchs show skeletal overgrowth and adiposity). The pituitary enlarges and becomes active after thyroidectomy and in myxedema, cretinism, and parenchymatous goiter, but is inactive in exophthalmic goiter, and during hibernation of animals.

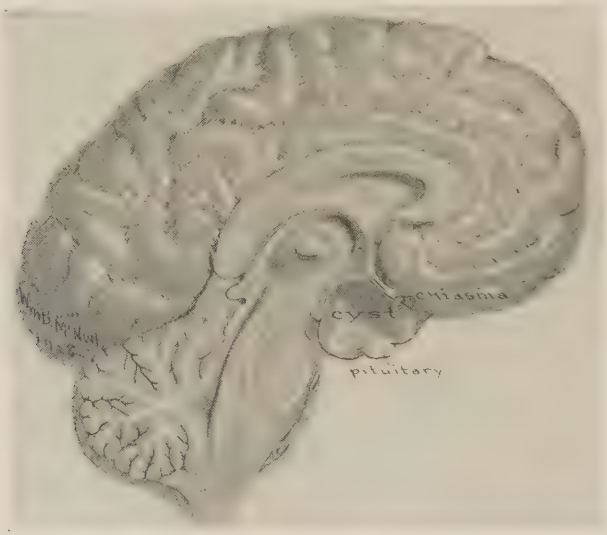


Fig. 341.—Cyst of the pituitary gland.

The lobes present combined as well as individual lesions; and with the atrophy and degeneration of an overactive pituitary, hyperpituitarism is succeeded by hypopituitarism. Where the type of lesion is not clear, the broad term "dyspituitarism" is used. Frequently the dysfunction concerns other glands of internal secretion as well as the pituitary, with resulting complexes (*polyglandular syndromes*).

Etiology.—Pituitary dysfunction may arise from:

1. *Suprasellar lesions* that press upon the adjacent pituitary gland, as tumor of the cerebrum or hydrocephalus.

2. *Pressure from below* from pharyngeal-pouch tumors; these occur in children, are associated with arrest in growth, and are frequently calcified so that they may be shown by roentgenogram.

3. *Primary Pituitary Disease:* Eighty per cent. consist of benign adenomas. Cystic degeneration of the pituitary is not uncommon.

Pituitary struma is a hyperplasia akin to that of parenchymatous goiter.

Symptoms.—In the child, hypopituitarism leads to dwarfing or infantilism, type Lorain; hypersecretion, to gigantism. In the adult, growth is not involved, but hypersecretion of the anterior lobe causes acromegaly; of the posterior lobe, Fröhlich's syndrome.

Pressure symptoms vary with the same lesion, but include:

1. *Headache:* Temporal, bitemporal or frontal deep between the eyes, probably from distention of the capsule of the pituitary.

2. *Blindness* from pressure on the optic chiasma; develops with: (a) reduction in the color fields, beginning with red; (b) central scotoma; (c) bitemporal hemianopsia, or occasionally homonymous hemianopsia; (d) unilateral blindness, present in about 50 per cent. of the cases, is not uncommon from a primary

Fig. 342.—Tumor of the pituitary gland.

optic atrophy, and may be associated with choked disk on the opposite side; (e) complete blindness is common in the late stages of pituitary tumor.

3. *Ocular palsy* from pressure on the third, fourth, and sixth nerves in the cavernous sinus is rather unusual.

4. *Physic change* from pressure upon the frontal lobe. Involvement of the hippocampal gyrus with cysts of the uncus may occur.

5. *Nasopharyngeal symptoms* include epistaxis, or the discharge of mucus or cerebrospinal fluid, occurs in tumors.

6. *Exophthalmos* from pressure upon the cavernous sinus is rare.

7. Trigeminal neuralgia, distention of the veins of the scalp and eyelids.

8. *Vomiting* and *choked disk* are unusual.

9. *Roentgenograms* show: (a) Increase in the sellar measurements; (b) atrophy of the posterior clinoid processes; (c) encroachment on the sphenoidal sinus. The sella may be hypoplastic and abnormally small.

Diagnosis.—Except with malignant tumors, the symptoms often are of slow evolution, lasting from four to twenty years. Headache, dimness of vision, first of one and then of the other eye, and changes in the sella turcica as shown by the roentgenogram are suggestive, and, when associated with the signs of pituitary dysfunction, are diagnostic.

Giantism refers to persons over 6 feet, 8 inches in height. Forty per cent. are from struma or tumor of the pituitary, developing before the completion of ossification. There often is associated physical and mental weakness, and death is frequent before the age of twenty years.

Treatment.—Subsellar decompression to relieve intracranial pressure and to preserve vision, preferably with the associated removal of the struma or adenoma to overcome the hyperpituitarism.

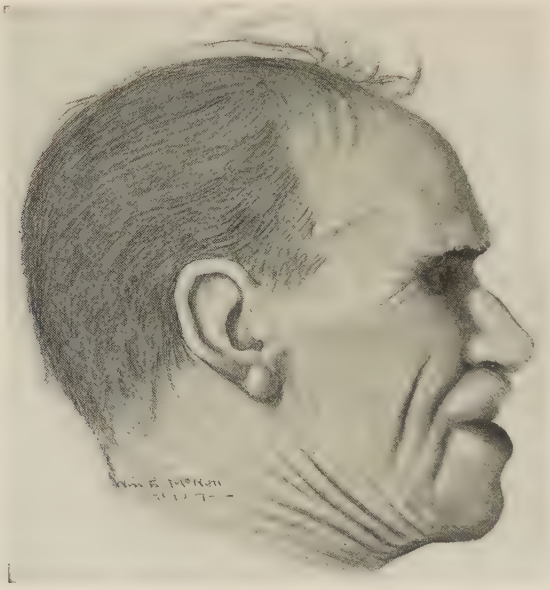


Fig. 343.—Acromegaly: Prognathism and heavy features.

Acromegaly is characterized by overgrowth of the face, feet, and hands. It occurs after adolescence, and is due to excessive activity of the anterior lobe of the hypophysis.

Etiology.—Is usually a simple fibrous or a malignant adenoma or a struma. It is never due to sarcoma. The bony overgrowth is chiefly from the periosteum, and involves: The bones of the head, especially the lower jaw, with increased spacing of teeth; the bones of the hands and feet, the phalanges being broadened and the terminal phalanges tufted; the thorax is increased in size, with enlargement of the sternum and clavicles; the soft tissues, skin, and subcutaneous tissues of the nose, eyelids, tongue, ears, hands, and feet are thickened. Kyphosis and lordosis occur. In the early stage there is glycosuria, hyperglycemia, increased physical strength, and libido; in the late stage hypoglycemia, high carbohydrate tolerance, and physical, cardiac, and sexual weakness. Mentality is not impaired. Sixty per cent. of the patients are men.

Prognosis.—Acromegaly usually begins in the third decade, may slowly progress for ten to fifty years, or may become arrested or improve. If due to a malignant tumor, death usually occurs within six years.

Treatment.—(1) Glandular feeding is of questionable value. (2) Radiation treatment is of value, and may be employed when vision is not threatened and there is no great danger in delay.

The progress of the disease should be determined by repeated study of the visual fields. Operation relieves the pressure symptoms, restores vision, and relieves headache, somnolence, fatigability, and reduces the size of the hands and feet and the excess of fat. Dysmenorrhea and amenorrhea tend to persist.

Operation may be done through the transfrontal or temporal approach, but the transphenoidal approach is preferred for primary intrasellar lesions.

Fig. 344.—A hand in acromegaly.

The mortality, in skilled hands, is 3 per cent.

Dystrophia adiposogenitalis of Fröhlich is due to deficient secretion of the pituitary, from tumor, degeneration, or injury. It is characterized by obesity, high sugar-tolerance, and arrest of development of secondary sexual characteristics. Before puberty the adiposity is enormous and universal, the stature may be greater than normal, genital dystrophy not marked, and early death may occur from the presence of a tumor. Developing during puberty, there is adiposity of the feminine type, overgrowth, high sugar-tolerance, excessive appetite, sexual infantilism.

Diagnosis.—Pituitary adiposity is of the lower girdle and mammary type. Thyroid adiposity (fat padding) involves the dorsum of the hands, feet, and back of the neck; while the deposit from gonad deficiency is over the trochanters.

Tumors of the Pituitary.—1. *Adenoma* (*chromophobe struma of Cushing*) does not cause local infiltration or metastasis, and is benign.

2. *Sarcoma* or *carcinoma.*

3. *Extrapituitary tumors* are rare, and include the infundibular tumors, especially teratoma, occasionally cysts or endothelioma; grow from pituitary rests, especially in the neck of Rathke's pouch.

Symptoms include those already given for pituitary dysfunction and pressure.

Treatment.—(1) Radiation. (2) Subsellar decompression. (3) Removal of tumor or cyst.

Operations.—1. *Subtemporal decompression* is of limited value, but may be used where there is evidence of a general increase of intracranial tension.

2. *Transphenoidal approach:* The superior and inferior nasal operations with temporary displacement of the nose and exenteration of the nasal cavities are now obsolete. The preferred transphenoidal approach is extranasal through

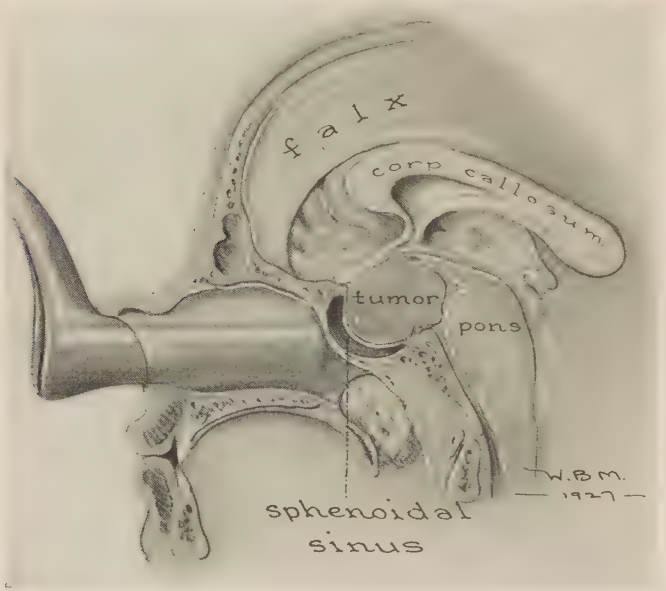


Fig. 345.—Tumor of the pituitary. Supralabial-extranasal approach. Transverse incision is made between the lip and nose, submucous resection of the vomer made, the floor of the sella turcica being reached without entering the nose.

a tunnel produced by the submucous resection of the nasal septum to the sphenoidal sinus (Kanavel-Halstead, 1909–10). The external incision may be (a) *Subnasal*, in which a 2- or 3-cm. transverse incision is made at the junction of the nose with the upper lip, or (b) *Sublabial infranasal* or *sublabial extranasal approach*, in which the upper lip is elevated and a 2-cm. transverse incision made across the labial frenum. In either case the posterior nares are plugged and a general anesthetic may be given by insufflation by a tube in the mouth or trachea. Narcolocal anesthesia may also be used.

The steps of the operation are: (1) Transverse incision with exposure of edge of the nasal septum. (2) Submucous resection of cartilaginous and osseous bony septum, including parts of the vomer and the lower part of the perpendicular plate of the ethmoid. (3) Dilatation of the tunnel up to 18 mm. by

dilating plugs followed by the introduction of a bivalved speculum with blades measuring 7 x 1.8 cm. (4) The posterior margin of the vomer is followed to the anterior and inferior wall of the sphenoidal sinus, which is removed. (5) The exposed thin floor of the pituitary fossa is broken away exposing pituitary capsule. (6) The pituitary capsule is opened by a hook-shaped knife.

As a rule there is little hemorrhage and the external incision is closed without drainage. The dura is not opened. If the approach is too far anterior, the cells of the ethmoid, the cribriform plate, and the dura may be opened with a secondary rhinorrhœa, meningitis, and death. The operation provides a subsellar decompression, enables the evacuation of cysts and the partial removal of tumors. Headaches from capsular distention, and ocular disturbances from chiasmal pressure may be relieved by the operation, and tissue removed for

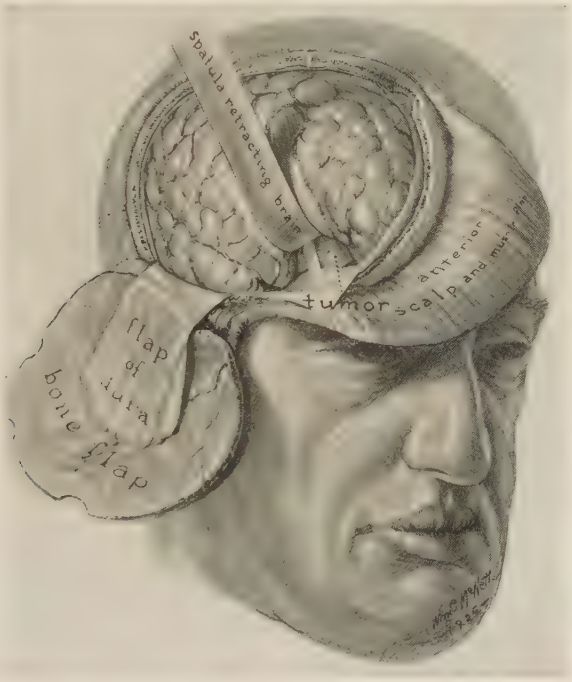


Fig. 346.—Frontal-parietal approach for the exposure of a pituitary tumor. The optic nerve is visible under the retractor.

biopsy. While useful for infrasellar and intrasellar growths, the transphenoidal opening will not relieve supra- and extra-sellar outgrowths, interpeduncular lesions, or the infundibular cysts. Electric illumination is necessary.

2. *Intradural approach* is accomplished by an extensive osteoplastic craniotomy and the elevation of the frontal or temporal lobe. The intracranial subtemporal approach has been abandoned on account of hemorrhage. In the frontal approach the osteoplastic flap (Adson) begins 3 cm. behind the external angle of the orbit and is carried just within the hairline to 2 cm. of the longitudinal sinus, where it passes backward 12 cm., then curving downward posterior to the parietal eminence to a point 4 cm. back of the

helix (technic of Heuer). The dura is incised along the upper, anterior and lower margins of the incision, the cortex protected by wet cotton, and the frontal lobe gently elevated, exposing the optic commissure and hypophysis. Invasion of the frontal sinuses during the operation may be followed by infection and death. Intrasellar growths are enucleated from within the capsule. The mortality is 30 per cent. (Adson).

Pituitary Implantation.—Cushing noted improvement of symptoms in hypopituitarism after a subcortical implantation of pituitary substance taken from a body of a newborn child.

PINEAL BODY

Tumors: Psammoma, teratoma, glioma, sarcoma, carcinoma, cysts, and gummata develop in the pineal gland.

Symptoms include papilledema, ocular palsy, ataxia, chorea, and athetosis. The gland is believed to have an inner secretion which may cause precocious puberty, increased size (*macrosomatia, macrosomia*), genital overdevelopment, obesity, and cachexia.

The **operative treatment** for growths of the pineal gland has not been developed. Glandular feeding may be tried.

SUPRARENAL GLANDS

The *adrenal* or *suprarenal glands* contain chromaffin cells, which also are found in small pea-sized bodies along abdominal aorta (*Kohn's paraganglia* or *chromaffin bodies*; *Zuckerkandl's organ*) near the origin of superior mesenteric artery, in the glomus caroticum (carotid bodies) at division of common carotid, and possibly in the glomus coccygeum (coccygeal gland, Luschka's gland).

Accessory suprarenal bodies (*suprarenal rests*), consisting of cortical substance, are found in the liver, broad ligament (Marchand's organ), and the solar plexus.

The *adrenals* are composed of a cortex and medulla:

1. The *cortex* (of mesoblastic origin) consists of: (a) Zona glomerulosa with columns of rounded cells. (b) Zona fasciculata, with lipoid granules. (c) Zona reticularis, with pigmented cells. The cortex influences growth, strength, mental development, and secondary sexual characteristics, including the growth of hair.

2. *Medulla* (of neuro-ectodermic origin) consists of strands of ectodermal chromaffin cells, blood-spaces, nerve-cells, non-medullated nerve-fibers. The active principle of the medulla is the internal secretion, *epinephrin* or *adrenalin*, which constricts peripheral blood-vessels with dilatation of coronary arteries, slows and strengthens the pulse, raises blood-pressure, increases glycogenolysis in the liver, causes hyperglycemia, and influences the pigmentation of the skin. The secretion is diminished in diphtheria and Addison's disease.

Hypoplasia and **hyperplasia** occur in osteogenesis imperfecta and osteomalacia. Cortical hyperplasia may occur in chronic nephritis.

Addison's disease, characterized by progressive weakness, and bronzing of the skin, usually affects males of between twenty and forty years, and is due to a secondary tuberculosis or, rarely, to atrophy or malignant disease of the adrenals.

Treatment.—That for tuberculosis, with feeding, injection, or implantation of the medullary substance of the suprarenal.

Tumors of Suprarenal Glands.—1. *Benign adenoma* and *benign hypernephroma* are usually small, but may be large and hemorrhagic.

2. *Malignant Tumors:* Carcinoma or sarcoma occurs at all ages, invades local structures including the vena cava, and gives metastases to lungs, bones (skull and vertebræ), kidneys, and lymphatic nodes.

Hypernephroma (*Grawitz's tumor, suprarenal rest in kidney*) is now considered to be a malignant adenoma or adenolipoma of the kidney.

Malignant adrenal tumors are of rapid growth, and may cause death within a few months. They resemble renal tumors, but do not distort the renal pelvis or cause hematuria.

Precocious development occurs with these malignant tumors in children, especially girls, with rapid growth, great strength, excessive hair, mental precocity, premature sexual development, deep voice, increased fat, and, at times, pigmentation. A child with such precocious development should immediately be examined for tumor of the adrenal.

Treatment.—Extirpation of tumor. Unfortunately, rapid recurrence and death are the rule.

Neuroblastoma arises in the medulla of the adrenals in childhood, and consists of undifferentiated nerve-cells or neuroblasts.

Pathology.—Delicate fibrils, supporting cells with a scanty cytoplasm and richly chromatic, rounded nuclei. The cells are arranged diffusely, or in the form of roulettes, around tangled masses of fibrillated or homogeneous material, staining faintly with eosin.

Symptoms.—Usually an orbital hemorrhage is the first sign observed, and occurs before the tumor of the adrenal is palpable. The orbit is, as a rule, involved on the same side as the tumor.

Fig. 347.—Precocious mental and physical development from malignant tumor of right adrenal in a girl of seven years. Rapid growth, unusual strength, excess of hair, bass voice, and advanced sexual development from the age of one year. (Referred by Drs. H. D. Jump and Henry Beates.)

Prognosis.—Invariably fatal. Surgical intervention is of no avail, metastasis probably occurs through the lymph-stream.

Part III

SURGICAL TECHNIC

CHAPTER XXIV

SURGICAL THERAPEUTICS

Resuscitation.—Somatic death, marked by the cessation of the heart, respiration and cerebral action, may be temporary and recoverable. The arrest of circulation must, however, be overcome within seven minutes or death is inevitable.

Molecular death, or death characterized by the death of the essential cells of the body, is beyond relief.

Artificial respiration is used for asphyxia, as from drowning, inhalation of gas, anesthesia, cerebral pressure or injury, or narcotic poisoning. The method used should be positive, should not damage the pulmonary alveoli as may occur from mechanical devices like the pulmotor, and should, if necessary, be continued for hours or days until spontaneous respirations have been resumed or until there is permanent cessation of cardiac contractions. Recovery has followed after it has been necessary to continue the artificial respiration for several days. Relays of assistants are desirable when the apnea is prolonged. Schäfer's method is preferred in asphyxia from drowning or gas. Babcock's method is adapted for asphyxia upon the operating table. A cotton indicator affixed to the tip of the patient's nose is always desirable. It is important that the respiratory movements be not repeated oftener than twelve to fifteen times a minute.

Silvester's Method (1858).—The patient being in a supine position, expiration is produced by compressing the sides of the thorax by the patient's arms grasped by the hands of the operator; inhalation, by fully extending the arms by the sides of the patient's head. Inhalation is aided by the elasticity of the chest and the pull of the pectoral muscles.

Marshall-Hall's Method (1857).—The patient being in a prone position, his forehead resting upon his wrist, a pad under the diaphragm, pressure is made with a brisk movement, along the back of the chest. The body is then turned on its side, and a little beyond, and then briskly returned to the prone position. The movements are repeated fifteen times in the minute, occasionally varying the side.

Howard's Method (1871).—Patient supine, cushion under the back, head low, hands together over the head. Expiration is produced by a firm inward and upward pressure for two or three seconds as the pressure is sharply released. The operator may kneel astride the patient's hips, and, bracing his elbows against his own sides, rock forward for expiration, aiding the compression of his hands by the weight of his body. As the operator rocks backward, releasing the pressure, inspiration occurs from the elasticity of the thoracic wall.

Schäfer's Method (1904).—The patient is turned face down (prone), with a pad (folded coat, blanket, or pillow) under the upper abdomen, the forehead resting on the flexed right forearm, the face turned slightly to the left, the left arm extended alongside the head. The operator, kneeling astride the patient's hips, gradually compresses the chest for three seconds from the back of the patient with movements as in Howard's method. This is preferred in drowning or gas asphyxiation.

Laborde's method (1897) is the stimulation of respiration by intermittent traction and relaxation upon the tongue.

Babcock's Method.—The method is used for asphyxia during operation. The patient being in a supine position upon the operating table, the wound is protected by towels and pads, the patient's arms extended alongside his head, the operator's hands are clasped over the patient's manubrium, his elbows being against the

Fig. 348.—Artificial respiration by compression of the chest wall.

lateral thoracic wall of the patient; and by gradual pressure downward, inward, and backward, expiration (shown by a wisp of cotton affixed to the patient's nose) is produced. Inhalation occurs from the elasticity of the chest and the pull of the pectoral muscles, as the pressure is quickly released. If the cotton indicator is not sufficiently moved, the operator steps to the patient's head, compresses the nose with his left hand, presses over the epigastrium with his right and, taking a deep breath, forcibly exhales through a thin towel or a few layers of gauze placed over the patient's mouth, producing mouth-to-mouth insufflation. Undue pressure cannot be produced in the robust adult chest, but excessive pressure should be avoided in children and the aged. It may be necessary to use a mouth-gag, and to pull the patient's tongue forward. Inhalation should be shown by the expansion of the patient's chest, exhalation should be audible. The pressure over the epigastrium is necessary to prevent distention of the stomach by air.

If tidal air is properly moved by the thoracic compression alone, the operator and his assistant may maintain the sterility of gloves and gown, being ready to immediately complete the operation or to introduce the hand in the abdominal wound for cardiac massage, should such prove to be necessary.

Methods of artificial respiration are seriously handicapped by regurgitant vomiting. The gastric secretions may flow into the pharynx or mouth, and the patient be drowned by his own fluids. The Meltzer-Auer method of intratracheal insufflation is not adaptable for an emergency.

On the regurgitation of gastric liquids the head of the patient should be markedly lowered and, if large quantities of fluid continue to well into the mouth as occurs in ileus, an aspirator should be used or tracheotomy should quickly be done and the air conducted through the tracheal opening. Of course the danger of regurgitation may be reduced by gastric lavage before the anesthetic is given, but at times even the lavage is insufficient. In respiratory failure before the respirations have ceased, a powerful stimulus may be obtained by the inhalation of oxygen containing 5 to 10 per cent. of carbon dioxid (Henderson and Haggard). Such inhalation should not prevent an early resort to artificial respiration when it is needed.

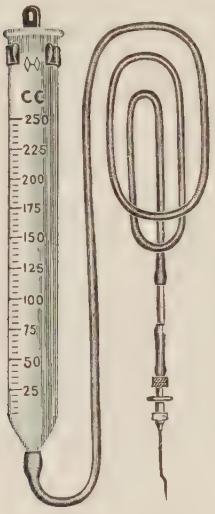


Fig. 349.—Apparatus for intravascular or subcutaneous injections.

In any case the circulation should constantly be watched. The difficulties of resuscitation are enormously increased by circulatory failure, and the patient will surely die if the heart absolutely stops for more than seven minutes. An early resort to infusion with epinephrinized saline insures against cardiac arrest, and an intravenous outfit should always be ready for instant use in every operating room. The smallest quantity of epinephrin solution that will produce the desired effect (from $\frac{1}{2}$ minim to 100 minims) should be used. Starting with 200 c.c. of saline solution containing 10 minims of the standard 1:1000 epinephrin solution the instant the pulse responds, even though but a few minims have entered the vein, the flow is arrested to be resumed later as required. If there is no response, the percentage of epinephrin in the saline is very rapidly increased until a response is evoked. An excess of epinephrin is harmful, putting, at times, an enormous strain upon the heart and vessels, and being followed by secondary circulatory depression.

Cardiac Massage.—With absolute arrest of the heart, a direct local *stimulus* is usually necessary to carry the epinephrin into coronaries, where it becomes effective. With the open abdomen, **subdiaphragmatic cardiac massage** is easily produced, but the operator should be careful not to have the left lobe of the liver interposed between the *internal hand* and the diaphragm. While it is the most successful method, it will occasionally fail where a transthoracic massage will stimulate the heart to action. It is not necessary to turn back a flap of the chest wall for transthoracic massage. A stab is made through the left fourth interspace 3 cm. from the sternum (to avoid the internal mammary artery), the finger introduced into the chest as the knife is withdrawn, and curled about the left

border of the heart which is rhythmically compressed against the overlying chest wall by flexing the finger (Babcock).

The **intraventricular injection of epinephrin** gives a violent stimulus to the heart that is very effective, and that has largely displaced the operative methods of cardiac massage. A 22-gage needle, 7 cm. long, is entered at the left border of the sternum in the third interspace, carried backward and mesially until the resistance of ventricular wall is past, then aspirated to prove that the point of the needle is in the free ventricular cavity, and the withdrawn blood reinjected with 5 or 10 ♏ of epinephrin by a Luer's syringe. These drastic procedures should rarely be necessary.

In all cases of resuscitation it is important to maintain the temperature of the body.

Perlingual Administration of Drugs (Paulson).—Morphin, atropin, epinephrin, pituitrin, nitroglycerin, strychnin, strophanthin, insulin (up to 30 units) are rapidly absorbed, from the sublingual space. The sublingual space is dried and the preparation in liquid, powder, or tablet form placed under the tongue, and swallowing withheld until the taste of the drug has disappeared. In adults the drug may be better retained in position by a pledget of cotton moistened with the solution, or containing the powder or tablet. With many drugs absorption occurs with a rapidity closely approaching that from a subcutaneous injection. Aromatic spirit of ammonia may be rubbed over the tongue of a comatose patient.

Pernasal Administration of Drugs.—A flexible tube, the size of a 10 to 20 French catheter, not more than 45 cm. long, is passed through the nostril into the pharynx, esophagus, and stomach, watching for evidence (choking, coughing, or movement of air from the end of the tube) that it has deviated into the trachea. If the tube enters the larynx or trachea it should immediately be withdrawn and reintroduced. After the tube has reached the stomach, the gastric contents should be aspirated to make sure that the tube is properly placed. A fine catheter introduced to the middle or lower esophagus is also efficient. Liquids, food, and medicaments may be introduced by the intermittent or continuous drop method, and gas and gastric contents aspirated from the stomach. The tube may be left in place for several days.

The **duodenal tube** is used for diagnosis, irrigation, aspiration, and feeding. In uncontrollable vomiting and purging it may be used to supply liquids. The metal tip and part of the rubber tube, moistened with warm water, are placed in the pharynx. The patient then drinks water, carrying the tube to the stomach. That the tip is in the stomach is shown by the aspiration of chyme. After one hour the tip has usually been carried by peristalsis into the duodenum, 70 cm. of tube having passed. The duodenal contents aspirated are golden yellow, watery, alkaline, and viscid. In an unconscious or delirious patient the tube is introduced on a piano wire, or by passing the tube through the nose. The Jutte tube may be left in the duodenum for hours or days, and is especially useful in ileus and acidosis. In thrombo-angiitis obliterans and other conditions with dehydration, 9 to 10 liters of Ringer's solution or other liquid may be given daily through the tube which, at times, is left in place for three to four weeks (Willy Meyer).

Proctoclysis, Murphy Drip.—*Rectal infusion* is used to supply nourishment and fluid to the patient. A glass, vulcanite, or soft-rubber tube is introduced 7 to 10 centimeters into the rectum, fastened by adhesive plaster to the patient's thigh, and connected by a container, the level of the fluid in which is not over 15 or 20 centimeters (6–8 inches) above the level of the rectum. The tubing should be large and without constriction to permit the free escape of gas or the temporary regurgitation of fluid from the bowel. The fluid introduced should be near the temperature of the body, under low pressure, and free from irritating qualities. It may conveniently be warmed by an electric light bulb placed in the container. An adult patient can absorb from 20 to 30 drops a minute or from 1500 to 5000 c.c. daily. Water or saline solution, with or without the addition of glucose, amino-acids, or alcohol, may be used. Fats, albumins, peptones, and starches are not absorbed from the colon and rectum.

Stimulating enema is used in shock and narcotic poisoning. A useful formula consists of tincture of capsicum, 8 c.c.; aromatic spirit of ammonia, 8 c.c.; glucose, 32 c.c.; warm decoction of coffee, 1000 c.c.

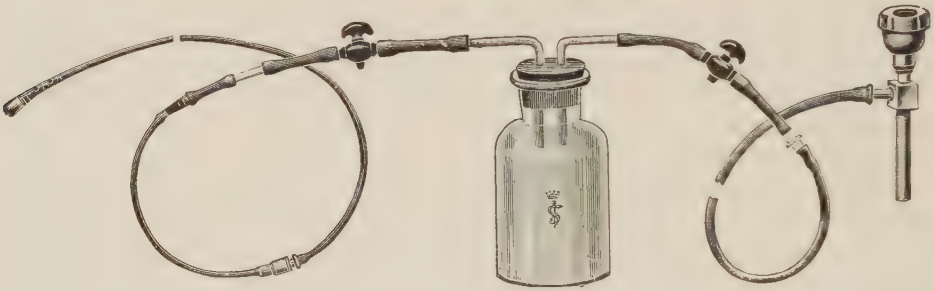


Fig. 350.—Jutte gastric or duodenal tube with aspirating bottle and aspirator.

Evacuant Enema.—**Soap-suds enema** consists of warm water containing 1 or 2 per cent. of soap. One or two liters are slowly introduced by low pressure at the temperature of the body. The addition of 8 c.c. of turpentine increases the activity of the enema.

Enemas should be avoided during the first two weeks after suture of the colon. Large enemas, 2 to 4 liters, have caused intraperitoneal leakage and peritonitis from the giving way of an appendiceal stump, a necrotic area of the bowel, or of an intestinal suture line, even a week or ten days after operation.

Triple enema consists of: Magnesium sulphate, 60 gm.; glycerin, 30 c.c.; turpentine, 8 gm.; water, 120 c.c. It is a very active, irritating, hygroscopic enema, stimulating peristalsis and the expulsion of intestinal contents including gas. To avoid proctitis it should rarely be repeated.

Milk-and-molasses enema, consisting of 120 c.c. each of warm milk and black molasses or honey, is a very effective evacuant, producing little irritation, and often effectual after other enemas have failed to give relief.

Alum enema (powdered alum, 15 gm.; water, 1 liter) is a powerful, irritating evacuant.

Asafetida enema consists of 500 c.c. of milk of asafetida. It is especially valuable for the relief of tympany.

Colonic Irrigation.—A two-way colonic irrigator with return flow, or a single rectal tube may be used. The irrigation is continued until 16 to 20 liters of water have been used. Hot colonic irrigation, the temperature of the solution being 115° to 120° F., aids in raising the body temperature in shock and collapse, gives great relief in postoperative gas-pain, and is soothing in pelvic inflammatory conditions, such as those involving the prostate, seminal vesicles, perirectal tissues, the tubes, ovaries, or uterus.

To prevent coiling, perforation, or other injury to the rectum a rectal tube should not be introduced over 10 to 15 cm. (4 to 6 inches). It is rare that a tube can be introduced past the valves of Houston without the aid of a proctoscope or other guide. The old division into *low* and *high enemas* is without anatomic or physiologic basis. Fluids introduced into the rectum are rapidly carried to the ileocecal valve, aided by the reversed currents of Bond. A long rectal tube, introduced through the anus for a supposed "high enema," merely coils in the rectum. All enemas, therefore, are high enemas.

Evacuant Suppositories.—(1) *Glycerin suppositories*, consist of about 3 gm. of glycerin solidified by sodium stearate. (2) *Soap suppositories* are fashioned from a non-irritating sodium soap by a knife or mold and by rubbing on a moistened cloth.

Endermic Injections.—The needle is introduced, beveled side up, into but not through the skin, parallel with the skin surface, until the bevel has been completely introduced. The injection is followed by the appearance of a white wheal. Endermic injection is used for strictly local effects or reaction, as: (1) *Skin tests*, including the Schick test, Dick test, and tests for allergic hypersensitiveness. (2) *Where slow absorption is desired*, as with tuberculin and certain vaccines, absorption being much slower than after the subcutaneous injection. (3) *Local Anesthesia:* Sloughing and necrosis much more frequently follows endermic than subcutaneous injections.

Endermic inoculation is used for vaccination against smallpox and in testing for hypersensitiveness: The skin is cleansed with alcohol and ether, then with sterile water, dried with sterile cotton or gauze, and scratched with a sterile needle or scraped with a scalpel to the true skin, so that the serum, but not blood, exudes. The virus or testing substance is then deposited on the spot and rubbed thoroughly into the abrasion, permitted to dry for a few moments, and then covered by a pad of sterile gauze with a hole cut in its center, and covered in turn by another layer of gauze held by bandage or adhesive plaster. Occlusive shields should be avoided. An improved method for vaccination consists in putting a drop of vaccine on the cleansed skin, which should be dry and free from antiseptic, and then make lateral pressure with the point of a needle to break through the outer epithelial layer at one or several points. No bleeding follows. The part is immediately wiped dry, and no dressing is required.

Subcutaneous Injections.—Hypodermic injection or administration consists of introduction of substances in the loose areolar tissue beneath the skin by a hollow needle attached to a syringe or collapsible container.

Technic.—A fold of skin is raised by the thumb and index-finger, and the needle quickly thrust through the skin at the base of the fold, and perpendicular

to the raised skin. Or the skin, if thick, is strongly stretched between the thumb and fingers, and the needle entered at an oblique angle to the surface. A diffusible soluble substance rapidly passes from the subcutaneous lymph-spaces into the blood-stream, producing its effect in from three to five minutes. The hypodermic dose is about one-half the oral dose. Epinephrin is absorbed slowly, due to the local vasoconstriction it produces. Absorption is delayed or imperfect in dropsical or edematous areas, or where the circulation is feeble or absent, as in shock or collapse, when the intravenous route should be preferred. Insoluble, non-diffusible, and colloid bodies are absorbed very slowly. Antitoxic serums require a number of hours. Insoluble mercurials may cause slowly appearing but progressive poisoning that may even necessitate the excision of the part.

Irritating drugs (as quinin, digitalis, alcoholic solutions, mercurials, calomel, mercuric salicylate, neo-arsphenamin) should not be given subcutaneously, but

Fig. 351.—Wrist-drop (radial palsy) following the intramuscular injection of 2 c.c. of a 50 per cent. solution of quinin and urea into the muscles of the right arm for pneumonia. Operation after six months with resection of necrotic and avascular muscle about the nerve and hersage of the degenerated nerve. Voluntary contractions of the brachioradialis and extensors of the wrist gradually returned, beginning about three months after the operation. (Dr. Joseph Scattergood.)

intramuscularly. If injected near an important motor nerve paralysis may follow. Irritating or non-sterile, markedly acid or alkaline solutions cause local inflammation, abscess formation, and necrosis. The solution should be clear, nearly neutral, and isotonic. If an oil is used it should be absorbable, as almond, olive, or lanolin, and not mineral or paraffin oil, which may form a paraffinoma. The bulk should rarely exceed 2 c.c., nor should the solution be too concentrated. The point selected for subcutaneous injection is usually the lateral surface of the arm over the insertion of the deltoid, or the lateral surface of the thigh away from important nerves or blood-vessels. Irritating injections should not be made into the thigh or leg on account of the increased disability. To reduce the pain 1 or 2 per cent. of procain may be added, hot applications made after the injection, or the part painted with tincture of iodin or camphor chloral. To reduce absorption from an overdose an Esmarch bandage is applied between the point of injection and the body, and an ice-bag or cold compresses applied locally.

Dangers.—Injection into a vein, infection, secondary neuritis, necrosis. The rather tender subcutaneous nodules that result from liquefaction of fat, following the injection of vaccines or other irritating material, should be removed by puncture with a small sharp scalpel and the evacuation of the liquefied fat.

Subcutaneous Infusion.—**Hypodermoclysis** consists in the introduction of quantities of fluid into the subcutaneous tissues, and may be continuous or intermittent.

The apparatus consists of a funnel, buret, or other container, connected by 1 to 2 meters of rubber tubing with a 14 to 18 gage needle of nickeloid or noncorrosive steel.

The area selected for infusion should be one of loose subcutaneous areolar tissue, the preferred sites being submammary and axillary. Less desirable are the subcutaneous areas of the abdominal wall, the space of Retzius, and the subcutaneous tissue of the thighs and buttocks. Where rapid absorption is desired, two or more needles may be used at one time. For the submammary injection the needle should be introduced well to the side of the gland, which is lifted from the chest wall, as the needle is introduced nearly parallel with the ribs, taking care not to enter the mammary tissue or an intercostal space. The rapidity of flow is regulated by the looseness of tissue into which the point of the needle has entered, and by the height of the container. For a single injection from 500 to 1500 c.c. may be introduced, at a rate not greater than 500 c.c. for each fifteen minutes.

The solutions employed include physiologic sodium chlorid solution, 0.7 to 0.9 per cent., and Ringer's solution. Distilled water, or Fischer's solution, should not be used subcutaneously on account of the danger of secondary inflammation and necrosis.

Continuous hypodermoclysis (Kanavel) is very desirable in dehydration, toxemia, and forms of asthenia. A needle is introduced just below each clavicle, in the submammary space, connected through tubing and a glass Y with a container, which is maintained at a sufficient height above the needles to insure continuous flow without too great swelling of the tissues. To reduce the local edema the container is lowered. The injection is continued for three or four days if necessary, and as much as 600 to 8000 c.c. of the solution may be introduced daily.

Intramuscular Injection.—The injection may be in a muscle or between muscles (*epifascial injection*). It has the advantage of rapid absorption and reduced liability to necrosis or abscess formation, when irritating substances are used. Intramuscular injection is preferred for the administration of: (1) *Antitoxin*, as diphtheria and tetanus antitoxin. (2) *Relatively insoluble* or irritating mercurial, arsenical, and bismuth preparations. The needle should be strong and of sufficient caliber (18 to 22 gage) to permit the introduction of any oily or thick preparation used.

The preferred site of injection is the upper outer quadrant of the buttock, above a line connecting the great trochanter and the posterior superior spine of the ilium. The needle should be wiped clean, and care taken that no leakage from the needle occurs during its introduction or removal.

In intramuscular injections the skin is pulled down while the needle is entered, the needle being introduced at an angle of 20 degrees from the vertical in a sagittal plane, and slightly inclined mediad (Stokes). A small air-bubble is retained in the syringe above the injection fluid to clear the needle. Aspiration is made by the piston as the needle is swiftly withdrawn, the tissue being pushed back in position, and pressure maintained for a short time.

The areolar tissue on the upper surface of the fascia forming the extension of the fascia lata covering the gluteus maximus (Wachselmann-Eiche) is the preferred epifascial area, especially when highly irritating or bulky injections are used. In this area the lymph-flow is free and unobstructed.

In children antitoxin is given in the outer surface of the thigh (into or below the vastus lateralis) or in the subscapular muscles. Secondary painful indurations or nodules are treated by rest, hot applications, painting with tincture of iodin, gentle massage.

Intraparenchymatous (thyroid gland) and intraneural injections are occasionally used.

Intraserous injections into serous cavities are made into the pleura, peritoneum, tunica vaginalis, and large joints.

Intraperitoneal Injections.—The peritoneum has great power of absorption. Through the peritoneum of a dog a quantity of salt solution equal to the weight of the animal is absorbed in from twenty-four to forty-eight hours. The fluid may be introduced at the completion of an abdominal operation by filling the abdominal cavity with warm saline solution as the final peritoneal sutures are being introduced. At other times the injection is made through a small trocar or needle, taking great care not to penetrate the intestines or other viscus. The intraperitoneal injection is made in infants and growing children where the subcutaneous method is not available, or as a substitute for the intravenous route. In children with obstinate vomiting, dehydration, or acidosis, the needle is introduced in an upward direction through the abdominal wall and peritoneum, in the median line just below the umbilicus, the bladder having been emptied. Warm physiologic saline is introduced in quantities of 100 to 150 c.c. for small children. The injection may be repeated every twelve hours. Peritonitis may follow, especially in poorly nourished infants. To avoid possible puncture of the intestines Weinberg introduces a dull needle through a prick in the skin, at the junction of the outer and middle thirds of a line connecting the navel with the anterior superior iliac spine. He uses saline solution containing 6 per cent. dextrose and 2 or 3 per cent. sodium bicarbonate. Fixed oils introduced in the peritoneum may remain one to six months before absorption. Mineral oils are encapsulated, with the formation of fibrous adhesions.

Intraperitoneal blood-transfusion has been used in infants and children, with citrated, modified and unmodified blood. In hemorrhagic disease of the newborn, with anemia, prematurity, athrepsia, acidosis, and in other exhausting diseases, 20 to 30 c.c. may be injected repeatedly.

The red blood-corpuscles are promptly absorbed in the peritoneal cavity, provided compatible blood is used and the patient is not too debilitated. In acute peritonitis the danger from free blood in the peritoneal cavity is to be remembered, and the injection is not to be used.

Subarachnoid injection (*intradural injection*, *intrathecal injection*, or so-called *subdural injection*) consists in the introduction of fluid into the cavity of the arachnoid. After lumbar injection the injected fluid spreads in the spinal subarachnoid about the spinal cord and brain-stem, but not the cerebral hemispheres. The movement of introduced substances depends on the slow normal circulation of cerebrospinal fluid, on diffusion, and on gravity. Blood-serum tends to fall below the level of the injection, the circulation being insufficient to send blood-serum or other heavy fluid in a direction contrary to gravity. To act upon the brain, serum or other fluids should be introduced into the cisterna magna. The choroid plexuses prevent the passage of chlorids, bromids, iodids, nitrates, ferrocyanids, salicylates, acetates, methylene-blue, fluorescin, biliary pigment, mercury, and arsenic (Mestrezat-Sicard, Camp-Catton, and others) from the blood into the cerebrospinal fluid. Ether, chloroform, and methenamin, however, enter the cerebrospinal fluid. The selective action of the choroid plexus interferes with satisfactory medication of the central nervous system. The absorption of diffusible substances or antisera from the subarachnoid space is so rapid that medicaments do not remain long in contact with the brain and cord. Irrigation of the spinal canal with physiologic salt solution causes irritation, convulsions, and death (Weed and Wegenforth). A modified Ringer's solution (sodium chlorid, 0.9 per cent.; calcium chlorid, 0.024 per cent.; potassium chlorid, 0.042 per cent.) is better tolerated in cats. Any fluid used should, therefore, be isotonic and also iso-ionic.

Variations in hydrogen-ion concentration (Dandy and Blackfan), either acidity or alkalinity, cause irritation. Antiseptics appear to be harmful in meningitis, with possible exception of ethylhydrocuprein, which may be of advantage in pneumococcic meningitis (Wolff and Lehmann). For injection, 0.05 gm. of ethylhydrocuprein (*optochin*) in 10 c.c. of distilled water is used.

As arsphenamin and mercurials are too irritating to be introduced within the dura, arsphenamized serum and mercurialized serum have been employed. One hour after 0.6 to 0.9 gm. of arsphenamin or neo-arsphenamin have been given intravenously, 40 c.c. of blood is withdrawn into a sterile centrifuge tube and allowed to coagulate, and then centrifugalized. The following day 12 c.c. of serum are pipeted off, and diluted with 18 c.c. of sterile physiologic sodium chlorid solution; the mixture is heated to 56° C. for half an hour, an equal quantity of cerebrospinal fluid withdrawn, and the serum slowly injected, preferably by gravity. Antimeningitis serum, preferably introduced by intracisternal or intraventricular injection, has halved the mortality of epidemic cerebrospinal meningitis. The intrathecal injection of tetanus antitoxin has been disappointing clinically. These antiserums are preferably diluted with an equal amount of sterile water to make them more nearly approximate the cerebrospinal fluid in composition. Iodized oil has been used for diagnosis by subarachnoid injection. Lipiodol (Sicard and Forestier) may give rise to troublesome secondary symptoms.

Puncture headache begins the day following the puncture, and is due to leakage and lowering of pressure (the brain being left without its water cushion) or to meningeal irritation. There is occipital headache, and in severe cases increased tension of the postoccipital muscles, with nausea, vomiting, dizziness,

mental confusion, and faintness. The symptoms are aggravated by sitting and exercise, and relieved by recumbency.

Intravenous injections refer to the introduction of quantities of fluid up to 10 or 20 c.c.; *intravenous infusions*, to larger quantities. The fluid is introduced by gravity or air pressure.

Technic.—The injection is made into any convenient superficial vein, usually the median cubital or the basilic vein at the bend of the elbow is selected. A vein of the dorsum of the foot or back of the hand, the external jugular vein, a varicose vein of the leg or, in infants, the superior longitudinal sinus may be used. A rubber band or rubber tube, applied with sufficient constriction to interrupt venous return but not the arterial flow, is placed above the point of

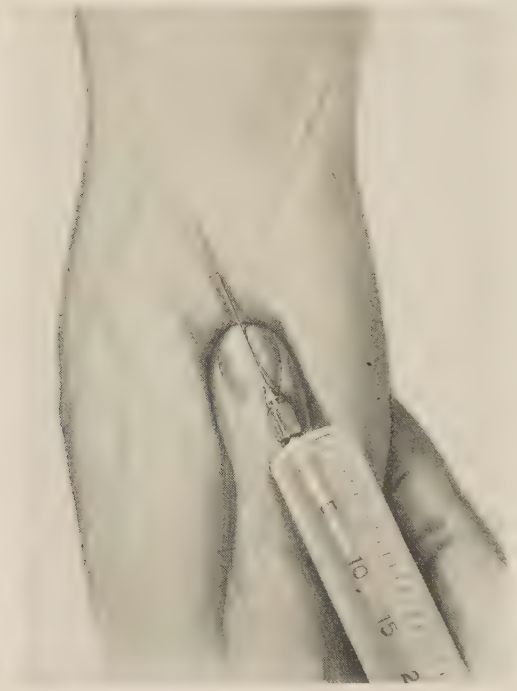


Fig. 352.—Technic of intravenous injection. Distention of the veins is produced by a constricting band proximal to the area of injection. The selected vein is steadied by pressure and traction of the thumb as the needle, held almost parallel with the surface of the skin, is introduced.

injection. By opening and closing the fist or by preliminary dependency of the arm the veins may be better distended. The bevel of the needle point should be straight and rather obtuse, not long, flat, or concave (Steel). A 20 to 24 gage, 1.5 to 2.5 cm. needle should be used. The vein is steadied by traction upon the skin below the point of injection with the thumb or fingers of the opposite hand. The needle, bevel up, is placed over the vein, parallel with the vein and at as acute an angle as possible; it is pushed through the skin with a lifting motion, care being taken not to transfix the vein. After introduction, as blood enters the syringe, the needle is pushed a short distance farther into the

vein and the rubber constrictor removed. The injection should be given slowly, about 1 c.c. per minute, the piston being pushed down with a screwing motion. If an irritating solution is used, blood is finally aspirated into the syringe before withdrawing the needle. The needle is quickly withdrawn, and pressure made over the point of puncture by a small gauze or cotton sponge wrung out of alcohol, and held in place by a circular bandage for two hours. If swelling or pain develops, indicating a paravenous injection, aspiration should be made and the injection stopped at once. If a quantity of very irritating solution, as salvarsan or calcium chlorid, has entered the tissues, a free incision should be made and hot 1 per cent. sodium thiosulphate compresses applied.

Vein Infusion (Venoclysis).—A straight or the angled Schreiber needle is introduced in the vein, being carried for at least 1 cm. into the lumen. With blood freely running from the needle, a graduated buret with $1\frac{1}{2}$ meters of rubber tubing from which the air has been carefully expelled, is connected to the needle and the infusion started. The rate of flow is regulated by the height of the buret above the vein. Very slow infusions produce the fewest untoward symptoms. The needle and adjacent tubing are properly supported, and carefully strapped to the patient's arm by adhesive plaster, and, if a prolonged infusion is to be used, the arm is bandaged to a splint or fixed support.

Infusion is used: 1. **To supply fluids** in dehydration, toxemia, acidosis, and alkalinosis. When enough blood has escaped to be surely fatal, saline infusion will not save the patient, and an excessive intravenous infusion after hemorrhage may kill the patient by overdilution of the blood. Infusion is very valuable, however, when there has been an excessive loss of fluid from vomiting, purging, or shock.

2. **For Intravenous Nutrition:** A 5 to 25 per cent. solution of tested glucose in saline solution is caused to slowly enter the vein. The infusion may be continued for five hours or more. Hendon has given 60 drops per minute (240 c.c. per hour or 6000 c.c. a day) of dextrose solution for eight days and nights. As a food, 2 liters of isotonic dextrose solution (4.76 per cent.) represent about 260 calories. A reaction with chill, fever, and sweat may follow the injection. The agglutination of red blood-cells is perhaps reduced by using a hypertonic solution (20 to 40 per cent. solution of glucose), or by the addition of sodium chlorid 0.1 to 0.2 per cent., dibasic potassium phosphate 0.1 to 0.2 per cent., and by the very slow injection of the solution. A large or rapid injection in a very weak patient, or one with myocardial degeneration, may be fatal. One hour should be consumed in giving 500 c.c. of a 10 per cent. solution of dextrose. The temperature of the fluid should be raised to about 105° F. by hot-water bottles, a heating pad, or other device applied to the tubing. In acidosis and fatty degeneration the carbohydrate is protective; in poisoning by chloroform or phosphorus the liver is protected. Acidosis is the result of the imperfect oxidation of fatty acids in the absence of sufficient proportion of oxidizable glucose.

3. **For stimulation:** Epinephrin or other stimulant being added to the solution. Epinephrin is the strongest analeptic, but is dangerous unless administered in dilution and very slowly. Five minims of the 1 : 1000 solution is the maximum dose for a person with good circulatory system, but in myocardial

degeneration much larger doses are required. For quick stimulating effect the flow of saline solution is started, and 3 or more minims of 1 : 1000 epinephrin solution injected by a fine hypodermic needle through the rubber tube just above the needle (Crile). As a rule, it is preferable to use more dilute solutions of epinephrin (3 minims being added to 200 c.c. of saline solution) in the buret. The flow of the solution is interrupted by pinching or clamping the tube the instant improvement in the pulse is noted, otherwise an excessive and harmful stimulation with strain upon the heart and vessels may be produced. If no response occurs from 3 minims, progressive additional amounts of the epinephrin solution are added until the desired stimulation is obtained.

For prolonged stimulation, a dilute solution of 1 c.c. of epinephrin to 1000 c.c. of saline may be permitted to flow into the veins at the rate of 20 to 100 drops a minute for hours or days. In latent hyperthyroidism a toxic crisis may follow. As a rule, intermittent stimulation with the smallest effective dose of very dilute epinephrin is preferable to the use of large doses and concentrated solutions. The epinephrin stimulation only continues twenty to thirty minutes, when, if necessary, the infusion should be renewed. If the heart has stopped, intravenous infusion usually fails until the heart has been emptied or directly stimulated by cardiac massage or injection. The epinephrin should enter the coronary arteries to be effective.

4. **For Intravenous Osmotherapy:** This is used to reduce intracranial pressure. The bulk of the brain and cerebrospinal pressure are reduced by an intravenous injection of a 35 per cent. solution of sodium chlorid (Weed and McKibben). With the tension headache of a cerebral tumor there may be an initial sharp rise followed by a profound fall in cerebrospinal pressure, which may last for hours. This results from absorption and decreased formation of cerebrospinal fluid.

Hypertonic infusions may cause reversal of the flow of cerebrospinal fluid, with absorption through the choroid and ependyma. Thus Corbus O'Connor and others give neo-arsphenamin intravenously six hours after 100 c.c. of 15 per cent. hypertonic salt solution has been injected, to produce an increased effect upon the cerebrospinal lesions.

Instead of salt solution a 25 per cent. dextrose solution may be used, 250 c.c. being given each hour (Haden). Osmotherapy causes dryness of the mouth, thirst, lessening of gastric secretions and gastric acidity, reduced secretion of milk, decreased thyroid activity, thyroid postoperative acidosis, and an anhydrotic effect in night-sweats. The diuretic action is not marked due to the inhibition of secretory action. The diuretic action is greater with sodium sulphate, 10 to 20 per cent. solution; urea, 20 c.c. of a 20 per cent. solution; or calcium chlorid, 10 to 20 c.c. of a 10 per cent. solution. Osmotherapy is not useful in cardiac decompensation or myocardial disease, when the injection of 200 c.c. of solution may be dangerous or even fatal, with chill, high fever, distress, pulmonary edema, and sudden cessation of heart. Even 30 or 50 c.c. may produce unpleasant effects.

The blood-pressure usually is not raised by hypertonic infusions. Sugar solutions dilate the capillaries, increase the venous pressure and the pulse pressure. A reduction in pleural effusions and a diminution of bronchial secretions

occur. Calcium chlorid infusions produce a shortening of the bleeding time, which, unfortunately, is of limited value in internal hemorrhage.

5. **Parenteral Alterative Therapy** (*Ergotropic or Non-specific Protein Therapy, Non-specific Immunization*).—The subcutaneous or intravascular injection of foreign protein excites the formation of protective substances similar to those formed against bacterial infections. The injection produces: (a) Increased temperature, followed by antipyretic action. (b) Decrease in number of leukocytes, leukopenia, followed by leukocytosis. (c) Aggravation of local inflammatory phenomena followed by amelioration of local symptoms. (d) Diminution followed by increase in immunity. (e) Decrease followed by increased clotting power of the blood. (f) Temporary lessening of allergy in such conditions as asthma or eczema or, an increase from excessive dosage.

Excessive dosage may cause paralysis, collapse, decreased resistance, spread of infection.

Technic.—(1) Injection of from 5 to 10 c.c of *distilled water* into the blood-stream producing protein shock by hemolysis (Schantz). (2) (a) *Autoserotherapy*, reinjection of blood-serum or serous effusion, or (b) *Autohemotherapy, intramuscular* or *intravenous injection* of the patient's own withdrawn blood. The blood may be modified, as by mixing with 5 c.c. of a 5 or 10 per cent. sodium chlorid solution. More violent reactions follow the intramuscular injection or intravenous injection of 10 c.c. of sterilized milk, or 1 c.c. of 0.1 to 1 per cent. sulphur in oil, or the intravenous injection of typhoid or gonococcic (1 to 3 minims) vaccine. These injections produce a violent chill and hyperpyrexia, and may be followed by improvement in gonorrheal, rheumatic, or other conditions.

6. **Thermotherapy** (*fever therapy*), produced by inoculation of the organism of malaria or relapsing fever, has been used with some success in paresis and in tabes. The intramuscular injection of 5 c.c. of blood from a patient with the active disease is less dangerous and should be preferred to the intravenous injection. The high fever (106° F. for hours) from the infection is bacteriostatic or germicidal for certain micro-organisms. After sufficient febrile effect has been obtained the induced malaria is cured by the use of quinin.

7. **Hemostasis.**—In jaundice and in other conditions with delayed clotting time from deficiency of available calcium, intravenous injections of calcium chlorid are used to arrest hemorrhage. Hypertonic calcium solution has greater osmotherapeutic action than other osmotherapeutic agents. Five to 10 c.c. of a 10 per cent. sterile solution is to be injected two or three times daily, or to prepare a jaundiced patient for operation, once daily for three days (Walters). The immediate reaction is a sense of heat over the body lasting but a few moments, and a depression of blood-pressure may be associated. The solution of calcium is useful in deficiency of the parathyroids, may increase the efficiency of digitalis, and of itself slow the pulse and lower the blood-pressure. If it escapes from the vein into the tissues, a severe local necrosis occurs.

8. **For Bacteriostatic or Bactericidal Action:** For malaria a 1 : 3000 solution of quinin dihydrochlorid or hydrobromid may be given at the rate of 10 c.c. per minute. Collapse may occur, requiring epinephrin or pituitrin. In certain specific infections the antiserum may be given intravenously. Tetanus

antitoxin is given both intravenously and subthecally. To avoid local irritation from the antimony and potassium tartrate given in leishmaniasis and bilharziasis, it must be given intravenously.

Dangers of Intravenous Therapy.—Salvarsan, calcium chlorid, sodium bicarbonate, and many other drugs produce necrosis if injected subcutaneously. Reactions from intravenous injections may be due to bacteria or their products in the distilled water, to the water used, or to chemicals, as lead, copper, and zinc, or alkali dissolved from the glass container or rubber tubing. Emulsoids and colloids, as agar, acacia, and gelatin, may even in dilute solutions cause profound blood-changes, violent symptoms, and even death. Serums of many lower animals produce hemolysis in the human blood.

Potassium is a neuromuscular depressant on intravenous injection, while the sodium-ion is relatively harmless. Calcium, which is harmless by mouth, may be toxic on intravenous injection. Magnesium given intravenously depresses the nervous system. Of a 10 per cent. solution of magnesium sulphate, 10 to 20 c.c. have been used intravenously as an antispasmodic in tetanus and eclampsia.

Emboli which are filtered out by the lungs must be present in the venous circulation in rather large numbers to be dangerous. Small numbers of emboli have been introduced into the circulation without appreciable ill-effect. Pulmonary embolism is shown by pallor and signs of shock, followed by dyspnea, cough, and weak, rapid pulse. The danger of air-embolism has been greatly exaggerated. No symptoms follow the introduction of a few bubbles of air into a peripheral vein. The danger of oil-embolism is very real, death having followed intravenous injections of 4 c.c. or even 1 c.c. of camphorated oil. Intravenous injections of emulsions, like milk, except in very small quantities, are not permissible because of the danger of embolism.

Protein precipitants, as copper sulphate or mercuric chlorid, may produce violent reaction because of embolism. Mercuric oxycyanid is safer.

Anaphylaxis is especially to be dreaded in the treatment of allergic conditions. In asthmatic and similar susceptible patients intravenous injections should, if possible, be avoided.

The **test for susceptibility** is by endermic injection of the serum or other material to be used. If a wheal appears within a half-hour, the intravenous injection should be abandoned; or else detoxication practised by the subcutaneous injection of very minute amounts, doubling the dose every half-hour (beginning with 0.25 c.c.) until 1 c.c. is given; then 0.1 c.c. is injected intravenously, and this dose is doubled every half-hour until the desired quantity has been administered.

To combat anaphylaxis, 0.5 c.c. of epinephrin should immediately be injected subcutaneously.

Contraindications to voluminous infusions are: Dropsy, pulmonary edema, and marked cardiac insufficiency. Premonitory symptoms of acute dilatation of the heart are a dry cough (which should be heeded as a danger signal) and the appearance of pulmonary râles.

Intracardiac injection (Schiff) is the most rapid and powerful method of cardiac stimulation known.

Technic.—The needle is entered in the third or fourth intercostal space, at the left border of the sternum and the upper margin of the rib. It passes along the edge of the sternum until the posterior surface is reached; then the needle-point is turned toward the midline and pushed through to the heart, until the resistance of the heart-muscle ceases and blood appears in the syringe. If the heart is moving, the movement is transmitted to the needle. The needle should be introduced and withdrawn while attached to the syringe to avoid pneumothorax or pneumopericardium, and during artificial respiration it should be done in the expiratory phase. As a rule, not over 1 c.c. of a strong solution of epinephrin should be injected.

Autohemotherapy: Twenty to 30 c.c. of blood is taken from a superficial vein and injected immediately into the thigh. In postoperative pneumonia and other infections it may be of value, the blood containing an antigen and antibodies capable of producing a degree of active and passive immunity.

Blood-letting.—1. **Phlebotomy (Venesection):** The median cubital or the basilic vein is usually selected. The bend of the elbow is asepticized, and a short distance above an elastic band applied about the arm with sufficient pressure to arrest the venous return; with the fist strongly clenched, the prominent vein is opened by introducing the knife at the side of the vein and cutting the vein obliquely from within out as the knife is withdrawn; the flow of blood is reduced by digital compression of the vein below the puncture, and is aided by relaxing and clenching the fist. The blood is caught in a convenient receptacle, and the flow arrested by releasing the constriction and applying a pad and bandage over the small puncture.

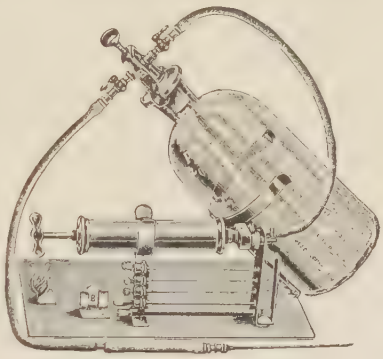


Fig. 353.—Potain's aspirator.

A *neater but slower method* is to introduce a large intravenous needle to which a section of rubber tubing is affixed. Phlebotomy may also be done through the great saphenous vein above the medial malleolus, a varicose vein, the external jugular vein; or in infants, by hypodermic needle into the superior sagittal (longitudinal) sinus.

2. **Arteriotomy,** using the superficial temporal artery or its frontal branch, is now rarely employed. The artery is incompletely divided until sufficient blood has escaped, and then the division is completed so that the ends of the vessel may contract and retract.

Aspiration is used for the removal of fluid for diagnosis or other purpose. Potain's aspirator consists of an aspirating needle connected by rubber tubing with a receiving bottle, which is also connected by tubing to a pump for the withdrawal of air. The pump need not be sterilized. The contained leather valves are destroyed by boiling. The needles and connecting tubing should be boiled. The air is first aspirated from the bottle, the stop-cocks closed, the needle or trocar properly inserted, and the flow of fluid into the bottle regulated by opening the connecting stop-cock.

Massage.—*Lubricants*, such as French chalk, talcum, cocoa butter, olive oil, vaselin, or lanolin, are desirable to prevent chafing, bruising, or dragging of hairs. *Effleurage* or stroking movements are first used. Weak and paralyzed muscles should not be stretched as are the healthy, unopposed muscles. *Tapotement* or *percussion* should never be performed on paralyzed or weakened muscles, but the *gentlest pétrissage* or muscle-kneading should be used, increasing in vigor as recovery progresses. Pétrissage is best performed with groups of muscles, with the muscles in a relaxed, supported position. Passive movements should be made slowly and gradually, and only up to the point of giving pain.

Counterirritation or **Revulsion:** Surface irritations, varying in severity from slight hyperemia to necrosis of tissue, are used to affect acute and chronic inflammatory processes.

1. **Rubefaction:** Hyperemia is produced by the application of (a) *heat*, as a hot-water bottle, electric pad, diathermy, or the more primitive well-wrapped heated stove lid, flat iron, or soap-stone. (b) *Cold* in the form of an ice-bag, ice-poultice (the cracked ice being mixed with bran or meal), cold compresses with pads of gauze wrung out of iced water or taken from a cake of ice. (c) *Prepared mustard plaster* or *sinapism*, which is applied after being wet with water, the intensity of action being reduced, when necessary, by interposing a layer of tissue paper. A paste made of mustard and cornmeal or flour is commonly used, the action of which is modified by the dilution, the admixture of white of egg, by greasing of the skin, or the interposition of tissue paper or thin cloth.

Turpentine is usually applied diluted in liniment, or sprinkled upon thick pads, preferably of flannel wrung out of hot water (*turpentine stupes*). *Iodin* is used when a less intense but more prolonged effect is desirable. The part is painted with the tincture or covered by a layer of the ointment. The tincture will produce a blister if covered by an occlusive dressing, or if kept moist against the skin.

Chloroform is used as a counterirritant in liniment, or mixed with tincture of iodin. Oil of gaultheria (*wintergreen*) and *oleum succini* (*amber*) are mild local irritants.

2. **Vesication** usually is produced by cantharides, using the official plaster, or the cantharidal collodion. When the blister is raised, the contents are aseptically removed by puncture, and boric acid or other simple ointment applied.

Ultraviolet rays, generated by the quartz light or carbon arc, produce erythema, vesication, and even necrosis of the skin.

3. *Ulcers*, *sinuses*, or *fistulous passages* were produced by the older surgeons for intense counterirritation, by: (a) The *actual cautery* (hot iron), gas or Paquelin cautery, or the galvanocautery. (b) *Moxa*—a cone of niter-impregnated cotton lint, or other inflammable material, ignited and held against the skin by a carrier or *porte moxa*. (c) *Caustic issue*, produced by the application of Vienna paste or other caustic. (d) *Knife issue* produced by a simple or crucial incision. (e) *Seton:* An artificial sinus produced by carrying a thread or skein of threads through the tissues or a fold of skin, the thread being retained as long as the counterirritation is desired. Suppuration is favored by pulling the threads, coated with savin or other irritating ointment, back and forth.

To increase the irritation and discharge, *issue-peas* (formed from wood, orris

root, or glass) were inserted into the tissues and held in place by plaster or other means. These methods are obsolete.

4. **Acupuncture** is produced by the introduction into the tissues of long, slender needles. The needles are left in place five to thirty minutes in case of neuralgia or neuritis, or immediately withdrawn if the object is to provide an opening for the escape of serum, as in edema.

Roentgenization.—By the passage of a high-voltage electric current through a suitable Roentgen tube a bombardment of electrons against the metal of the anticathode is brought about, producing the *x*-rays. With high voltages, hard or penetrating rays are produced; with lower voltages, soft rays, which, instead of penetrating deeply, are absorbed by the tissues. A *full erythema dose* is one that will be followed by transient redness and irritation of the skin, appearing about ten days after the treatment. If this dose is greatly exceeded, a Roentgen burn with necrosis and prolonged and often intractable ulceration may follow.

The activity of the ray diminishes in geometric ratio with the distance. For the deep treatment of tissues *cross-firing*, or the focusing of the rays upon the deep lesion through many blocked-off areas on the skin surface, is employed. All of the rays reach the lesion, and only a fraction of the rays pass through a single area of the skin, thus reducing the skin irritation.

In *tuberculosis of the lymphatic glands*, *skin*, *bones*, and *joints* radiation is of great value, but should be supplemented by general constitutional treatment and the use of the ultraviolet rays.

Pustular lesions of the skin (*acne*) and dry, infiltrating, and crusted forms of eczema are usually markedly benefited; also seborrheal dermatitis. The treatment of *sycosis* is aided by the epilation produced by four-fifths of an erythema dose. Permanent epilation by means of radiation for the removal of hair should not be used on account of the secondary telangiectasis, scarring, and ulceration of the skin that may follow. Roentgen-ray treatment should not be used during pregnancy, and those conditions complicated by active suppuration, liquefaction, inflammation, or degeneration.

The treatment is of some value in *hypertrophy of the prostate*, of great value in hypertrophy of the *thymus*, and of value in one-third or one-fourth of the cases of *hyperthyroidism*. In *leukemia*, irradiation of the spleen, glands, and bones is often followed by a marked but temporary benefit. In *splenomegaly*, especially in the splenomedullary leukemia, preliminary radiation of the spleen markedly reduces the mortality of splenectomy.

Electricity.—*Current* is a flow of electrons. *Voltage* is the intensity or pressure of the current; *amperage*, the quantity of current; the units being respectively the *volt* and the *ampere*. The *milliampere* is the recognized measure of the quantity of current used for therapeutic purposes. Various types of current are produced by variations in volume, intensity, interruption, reversal, and electrical induction—such as galvanism, faradism, sinusoidal and static currents.

Within limits, continuous, interrupted, or alternating currents (entering the body directly through various conducting media or by induction) produce structural and metabolic alterations:

1. **Directly,** from chemical compounds produced by electrolytic action.

2. **Indirectly,** from the transformation of the current into heat, muscular contraction, or other form of energy. The effects produced vary with the character of the current, the amperage, the electromotive force, the thoroughness of contact, and the resistance of the tissues. The effect is also intensified by the passage of the current through the ground. The human body offers a constant minimum resistance of about 3000 ohms to the passage of electric currents. The resistance of the epidermis is marked, especially if it be thick and dry, while the nervous tissues are relatively good electric conductors. The intensity of the current is equal to the electromotor force, having as its unit the volt divided by the resistance.

As a rule, the alternating are more dangerous than continuous currents, for with an alternating current of 500 volts the oscillation produces a difference in current potential of 1000 volts. Alternating currents, however, produce a minimum of electrolytic dissociation of the tissues, the alternations causing opposite chemical actions that tend to neutralize each other.

The effects of sinusoidal currents vary with the rapidity of the interruption. Above 5000 alternations a second, many thousand volts may pass through the body without discomfort; whereas if the alternations should drop to between 200 and 500 per second, death may result. The momentary application of high-frequency currents may be less serious than more prolonged applications of currents of lower frequencies.

Electricity may cause death by depression of the vital centers, by local tissue destruction, or according to d'Arsonval, by the heat generated by excessive muscular contraction.

High-frequency currents are those whose interruptions are too rapid to cause the usual electric responses by muscles and other tissues. The interruptions employed vary from 500,000 to 2,000,000 a second. The tissue resistance to the passage of high-frequency current results in the production of heat. By different windings of the coils used (1) a *moderate heating* effect with a high voltage is produced (the *Tesla current*); (2) a more *marked heating* effect and lower voltage (the *Oudin current*); or (3) a very *intense heating* effect and still lower voltage (the *d'Arsonval current*). The Tesla and Oudin currents use a single pole, the d'Arsonval two poles, one wire being attached to either end of the coil. By the high-frequency d'Arsonval current are produced:

1. *Autocondensation* or *general diathermy*, which warms the entire body, stimulates metabolism, tends to lower hypertension, and increases the elimination of urine and solids.

2. *Local diathermy*, producing hyperemia, relaxation, leukocytosis, and analgesia. It is useful in the application of heat to deep structures such as joints.

In using these currents, large electrodes (150 square cm.) are employed, the dosage usually being between 500 and 1000 milliamperes; the current being slowly and gradually applied, and continued for twenty minutes or more. To avoid burns, the electrodes should be large and not wet.

Electrodesiccation, used for the destruction of tumors or tissues, is produced by a monopolar high-frequency current of the Oudin type, the current being conducted to the part by a pointed metallic applicator, a single or multiple spark gap usually being used in the circuit. The tissues are desiccated or de-

hydrated. The power of a monopolar current cannot be accurately measured by a milliampere meter, but is determined by experience. The intensity of the action varies as the current is delivered to the tissues through a small air gap, or by insertion of the conducting needle into the tissues. When accurately localized, the effect may be produced in a very limited field with a minimum of scarring or secondary inflammation. Desiccation is desirable for the removal of small growths adjacent to important structures. Ulcer of the cornea, trachoma, a mole, papilloma, angioma, leukoplakia, and lupus vulgaris may thus be treated.

Electrocoagulation is produced by the bipolar high-frequency d'Arsonval current with a multiple spark gap. It has a lower voltage and a higher amperage than the Oudin current, and is used for larger and deeper growths, even those involving bone. The effect of the high-frequency current is purely thermic, and not electrolytic.

The second electrode may be a large, moistened asbestos pad. From 200 to 2500 milliamperes are used, depending on the size of the growth. Needles of steel or other metal are employed. The effect is less intense if the needle is not in direct contact with the tissues. The heat produced is more penetrating than that from the actual cautery.

After the electric destruction of tissue, the destroyed part is removed by scraping, excision, or incision, and further application made if necessary. Devitalized tissue should not be removed from mucous surfaces on account of the danger of hemorrhage. A severe secondary hemorrhage may follow if large vessels are in the path of the destructive current. This renders preliminary ligation in such a case desirable.

These methods are used for malignant tumors that have not produced metastasis, especially basal-cell epithelioma and localized squamous-cell epithelioma involving the skin or the mucous membrane, the urinary bladder, the larynx, or conjunctiva.

The tongue may be amputated after electrocoagulation of the base and a precautionary ligation of both lingual arteries. The least differentiated cells are those that are most vulnerable to heat. With malignant growths the operations should be completed in a single séance. Desiccation with its better localization produces less scarring than the method by coagulation. Desiccation is advocated by W. L. Clark for hemorrhoids and anal fissures.

Radiation is employed for non-localized malignant lesions, the local electric destruction usually being preferred for well-localized disease.

CHAPTER XXV

BANDAGING

Bandages are used for the retention of dressings, to give support, to prevent muscular spasm, and to retain warmth. Bandages are used for protection, compression, retention, fixation. A bandage consists of a strip of supporting material, which varies in length and width.

The **roller bandage** is a compact cylinder or roll, formed by winding the strip of fabric or other material upon itself. A single bandage or *single roller* consists of but one roll; with a *double roller*, the fabric is wound from each end, forming two rolls or a double-headed bandage. A bandage has an upper and lower edge, inner and outer surface, a body, an initial and a terminal extremity. Roller bandages are made of strips of gauze, muslin, flannel, canton flannel, cotton batting, crinolin, or rubber. Roller bandages vary in width from $1\frac{1}{2}$ to 20 cm. or more, and in length from 1 to 10 meters. Bandages may be rolled by

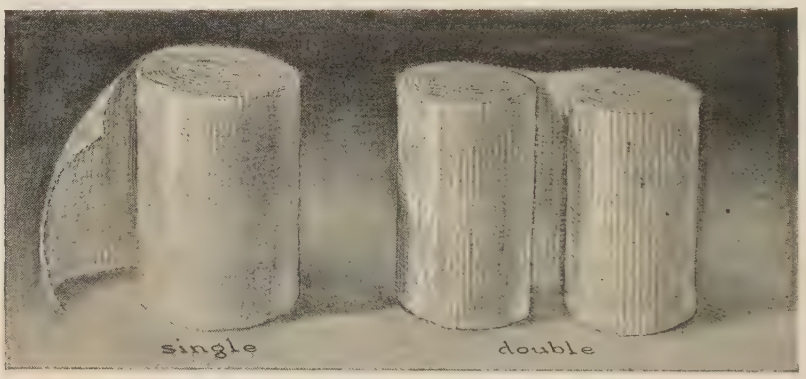


Fig. 354.—Single and double roller bandages.

hand or by a machine or bandage roller. After being applied to the body the bandage is prevented from unrolling by the insertion of safety-pins or the application of strips of adhesive plaster over the bandage. The bandage should not constrict or interrupt the circulation of a part unless it is deliberately applied as a tourniquet. It should be applied evenly, neatly, and the tension slightly decreased as the limb is ascended. If secondary swelling is to be feared, the bandage should be applied from the toes or fingers, the tips of which are left exposed, and the bandage immediately loosened if there is swelling, lividity, or pallor. A *bandage should always be applied with the part in the position in which it is to be maintained.* Joints and muscles are not to be flexed after the application of the bandage for fear of vascular constriction. Epithelial surfaces should always be separated by fabric or cotton to prevent maceration and ulceration.

On an extremity the bandage is usually first *fixed* by one or more circular turns at the point of least diameter, as the ankle or wrist. The end of the bandage should not be placed over a sensitive part.

Fig. 355.—Spiral bandage of a single finger fixed at the wrist.

Bandages are divided into: 1. **Circular bandages,** in which simple circular turns are taken about the part.

2. **Spiral bandage,** in which each turn covers about one-half of the preceding one.

Fig. 356.—Spiral reversed bandage of the forearm, figure-of-8 turns of the wrist and hand.

3. **Spiral Reverse:** Where the limb increases in size from below upward, the bandage is fixed by the thumb and reversed so that the inner surface of the bandage becomes the outer upon each turn. The reverses are used to better coapt the bandage to the part until the calibre of the limb becomes uniform.

4. **Oblique bandage,** one applied with oblique turns.

5. **Recurrent bandage,** one in which the turns recur successively to the same point. It is used for the head, an amputation stump, the end of the finger, or

the fist; it should carefully be pinned to prevent displacement of the recurrent loops.

6. **Figure-of-8 Bandage:** The bandage is applied in the form of a number of open loops, interdigitating in figure-of-8 form. (a) *Descending figure-of-8 bandage* of the extremity without reverses is largely used upon the leg, where it is more secure and gives better support than the spiral reversed bandage. The bandage is fixed by two circular turns around the ankle and, if desired, the bandage may then be carried about the ankle and foot to finally ascend by coarse separated spirals to the knee; the leg then being bandaged by accurately applied, descending, overlapping figure-of-8 spirals, each of which covers about one-third of the loop above. (b) *Spica Bandage:* A figure-of-8 bandage in which the loops are larger around the proximal than the distal part; used for the shoulder,

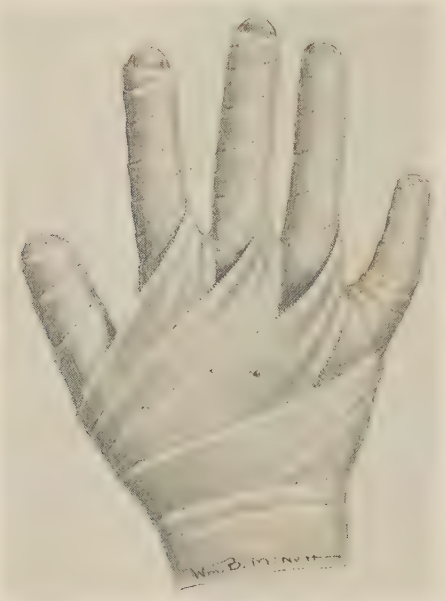


Fig. 357.—The gauntlet roller bandage of the hand, wrist, and fingers.

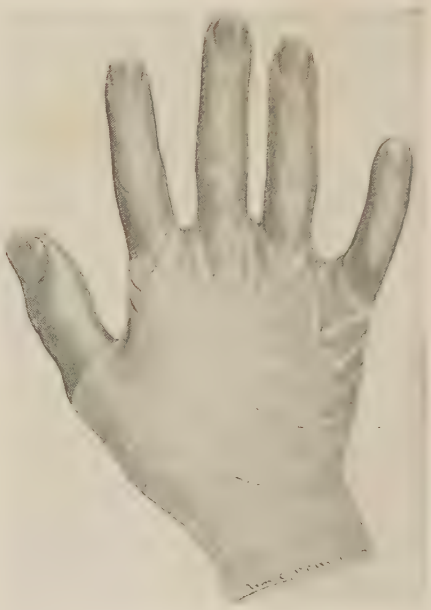


Fig. 358.—The demigauntlet roller bandage applied to the hand and wrist.

groin, thumb, and toe. According to the direction of application, the spica may be *ascending* or *descending.*

7. **Twisted bandage** is a variety of a double roller bandage usually applied to the head with half turns or twists where the two rolls meet to give better fixation and greater pressure, or to prevent displacement.

8. **A knotted bandage** is also made with a double roller and, where the turns meet, a hitch or knot is applied for pressure or for greater security. It is used for the head or other parts.

Special Roller Bandages.—Barton's bandage (6 meters by 5 cm.) is used for fractures and dislocations of the lower jaw, and for suspension of the head. It begins under the occipital protuberance, passes obliquely upward and forward under the right parietal eminence across the vertex, over the left zygomatic

arch, under the chin, upward over right zygomatic arch and vertex, and then down and back to the occiput. It is then carried forward under the right ear, around the front of the chin, and back to the starting-point. These turns are repeated three times.

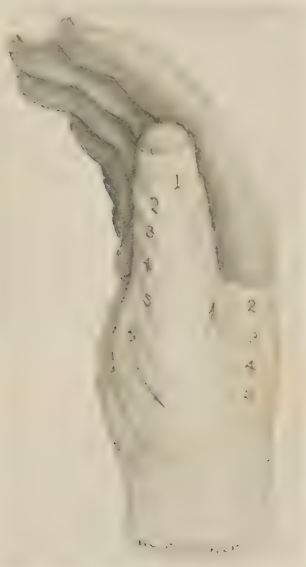


Fig. 359.—Ascending spica of the thumb.

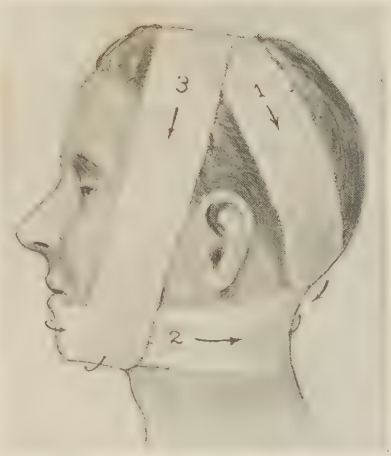


Fig. 360.—Barton's bandage. The turns are usually applied in the order 3, 1, 2.

Fig. 361.—Gibson's bandage.

Fig. 362.—Recurrent bandage of the head. This bandage may be applied with a single or double (capeline bandage) roller.

Gibson's Bandage (6 meters by 5 cm.).—From the vertex the roller passes downward in front of the left ear under the chin, up in front of the right ear to the point of starting. This turn is repeated twice, when, at the right temple, the bandage is reversed and carried horizontally around the head, from forehead to

occiput, three times. From above the right ear the bandage is then carried downward around the nape of the neck, under the left ear, around the front of the chin, beneath the left ear to the nape of the neck (repeated twice), when a reverse is carried over the top of the head from the neck to the forehead. Each intersection is fixed by pins.

Recurrent Bandage of the Head (6 meters by 5 cm.).—From the right temple two horizontal turns are made, to which, from the center of the forehead to the occiput, recurrent overlapping turns are carried alternately on each side of the median line, each covering two-thirds of the preceding turn until the occiput is completely covered; then the bandage is secured by two additional horizontal turns and the application of pins. During the application an assistant fixes the bandage at the points of recurrence.

Capeline: A double-headed bandage which starts at the forehead, the two heads passing around the sides of the head cross below the occiput. The lower head is now turned from under the upper head forward over the occiput to the forehead, where it is bound down and fixed by

Fig. 363.—Binocle or bandage for both eyes. A single or double roller may be used.

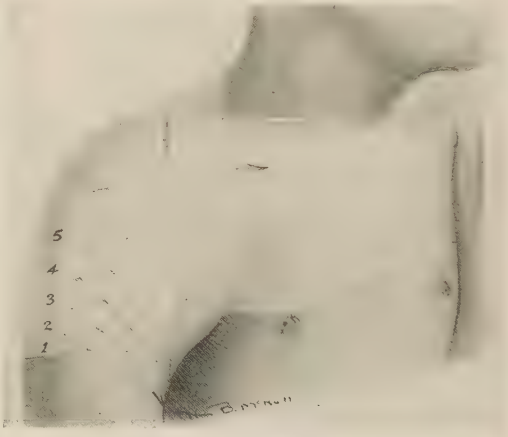


Fig. 364.—Ascending spica of the shoulder.

the upper head which, continuing around the forehead, again fixes the recurrent turn at the occiput. The turns are continued until all or the desired part of the head is covered. To prevent slipping the ends of the reverses should be below the occipital protuberance.

Crossed Bandage of the Eye (5 meters by 5 cm.).—For the right eye the roller starts at the right temple, and is fixed by two horizontal turns from forehead to occiput, from left to right. Arriving the second time at above the left ear, the bandage is passed down under the occiput under the right ear, obliquely over the left cheek and eye to the side of the head. This is continued in overlapping circular and oblique turns until the eye and ear on the affected side are covered, cotton being placed between the ear and scalp to prevent discomfort.

Spica of the Shoulder.—The bandage is fixed by a number of turns around the upper arm from without inward, continued until the axilla is reached, when

it is passed forward across the front of the shoulder and chest, beneath the opposite axilla, around the back of the chest, over the shoulder and anterior axillary fold, beneath the axilla, the alternating figure-of-8 turns being repeated.

Spica of the Groin.—The patient's sacrum being supported by a padded block, pelvic rest, or inverted basin, the bandage is fixed by two or three circular turns taken around the upper part of the thigh from within outward, and then carried from the medial side of the thigh outward along the groin, around the back of the pelvis, across the pubis to the lateral side of the thigh, around which a turn is taken, to be followed by another around the pelvis. Each succeeding turn should be a little higher than the preceding one. The bandage should be kept below the level of the iliac crests.

Saint Andrew's cross is a double spica of the groins.

Velpeau's bandage (8 meters by 7 cm.) is used for fractured clavicle and for support and fixation of the arm to the chest. The arm is placed in the Velpeau position, the hand being upon the opposite shoulder and the elbow near the ensi-

Fig. 365.—The Velpeau bandage.

form. A towel or pad is placed in the axilla and between the arm and chest, to prevent maceration of the skin. From the opposite axilla the bandage ascends across the back over the affected shoulder, passing down across the middle of the arm to curve behind the elbow and the anterior chest to the point of origin. A horizontal turn is now made level with the affected elbow, and the horizontal and vertical turns alternated until the affected shoulder, elbow, and forearm to the wrist are covered. The horizontal turns overlap the preceding turns two-thirds, the vertical turns overlap the underlying turns one-third. The vertical turns progressively descend to the point of the elbow, the transverse turns ascend to the wrist. Often the bandage is completed by several circular turns around the chest, arm, and forearm.

Desault's bandage consists of three rollers, each 7 meters by 5 cm., and is used for fracture of the clavicle and for fixation of the shoulder and arm: (1) The *first roller of Desault* is applied with a wedge-shaped pad in the axilla, the

arm at the side, the forearm at right angles to the arm. The wedge-shaped pad, three finger breadths in width, reaches from the armpit to the elbow. The first roller merely retains the pad to the side of the chest by descending circular turns about the pad and chest, beginning at the sound axilla. Each turn covers one-half of the preceding turn until the level of the elbow is reached, when the circular turns are made to ascend to the point of starting. To better support the pad, the bandage may terminate with a figure-of-8 turn about the opposite shoulder. (2) The *second roller of Desault* starts at the sound axilla, and descends circularly from the shoulder to the elbow, fixing the elbow to the side. (3) The *third roller of Desault* (*A. S. E.*, or *axilla-shoulder-elbow bandage*) begins in the axilla of the sound side, passes across the back over the affected shoulder, down the front of the arm under the elbow, to ascend across the back to the point of starting. A similar axilla-shoulder-elbow turn is now made from the front of the chest, and the alternating turns are repeated two or three times, each turn covering two-thirds of the preceding one. The bandage lifts the shoulder upward and backward, and is usually completed by several circular horizontal turns around the chest and arm.

Fig. 366.—The three rollers of Desault.

Tailed bandages consist of a body, to be placed over the affected part, from which extend narrower strips or tails (usually formed by tearing or cutting the bandage), which are so carried about the part of the body and fastened as to fix the bandage in place. The bandage may be given the name of the part to which it is applied, as an *abdominal bandage;* or named after its shape, as a *T-* or *Y-bandage*, in which the strips of fabric are so united as to resemble the letters T or Y.

A **single T-bandage** is largely used for supporting dressings about the perineum. The tail is split for the male patient, so that the ends pass about the scrotum. A broad triangular tail is desirable where a large dressing is to be supported.

A **double T-bandage** is useful for the support of the mammary glands. A double T-bandage is also used for the abdomen: The broad part or *binder*, encircling the abdomen, is prevented from slipping upward by the two narrow vertical portions, which are carried about the thighs and fastened to the binder.

Four-tailed Bandage of the Head.—A rectangular piece of muslin or other fabric, about 20 by 70 cm., is used. Four tails are formed by tearing from each end to within 8 or 10 cm. of the middle. The bandage is placed over the re-

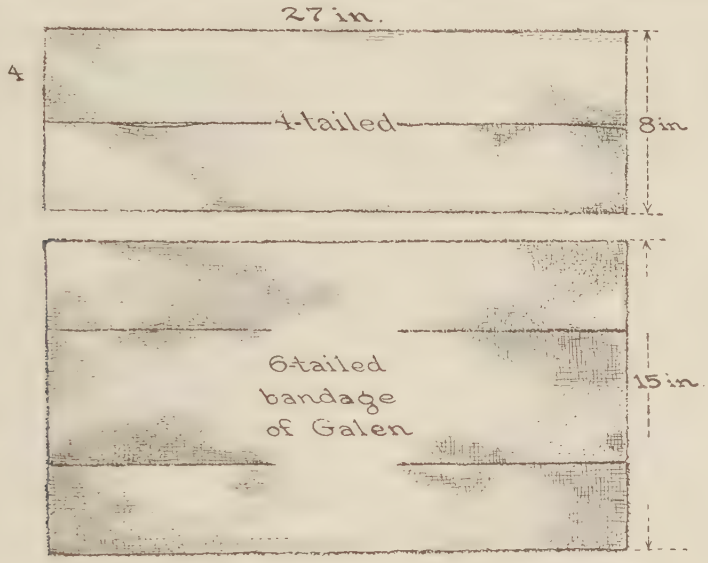


Fig. 367.—Four-tailed and six-tailed bandage.

quired portion of the scalp or forehead, and each set of tails carried at right angles to the other and secured by pinning or tying under the chin and occiput.

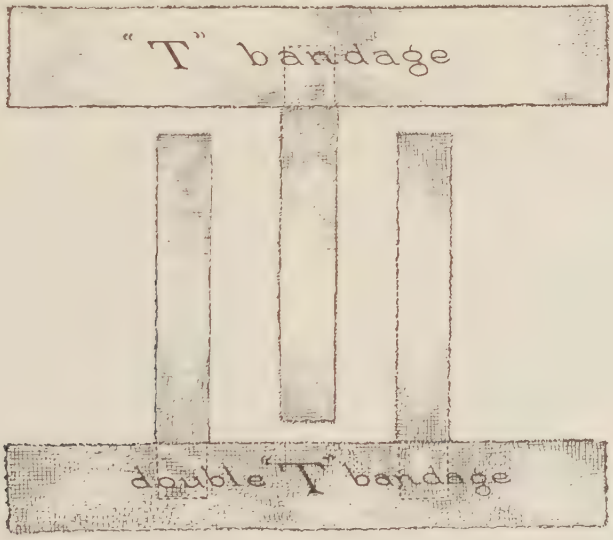


Fig. 368.—Single and double T-bandage.

A four-tailed bandage, the ends of which are fastened respectively about the neck and forehead, is useful for holding dressings to the back of the neck.

Six-tailed Bandage (Galen's Bandage, Poor Man's Bandage).—A rectangular piece of fabric, about 38 by 70 cm., is so torn from the ends as to form six tails, the two middle tails being wider than the lateral ones. It is used to cover the

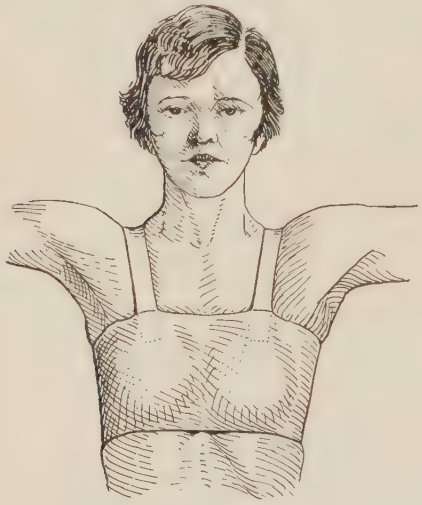


Fig. 369.—Two-tailed T-bandage, used as a binder for the mammary gland.

Fig. 370.—Use of four-tailed bandage for retention of dressings to occiput.

entire scalp, to which it is applied transversely, the broad tails being fastened under the chin, the two anterior tails being carried backward and fastened under the occiput, the posterior tails being carried forward and fastened over the forehead.

Fig. 371.—Four-tailed bandage used for the retention of dressings to the occiput and vertex.

Fig. 372.—Use of six-tailed bandage for the retention of dressings to the head.

Scultetus or **many-tailed bandage** consists of many short overlapping strips of bandage, united near the center, the ends or tails of which are wound about

the part to be supported. The scultetus bandage is largely used as an abdominal binder.

Handkerchief bandages are made of square pieces of muslin or other fabric, which may be folded to form a *rectangle* or *triangle*, or loosely folded or rolled together to form a *cravat*, or twisted to form a *cord*. The corners of the

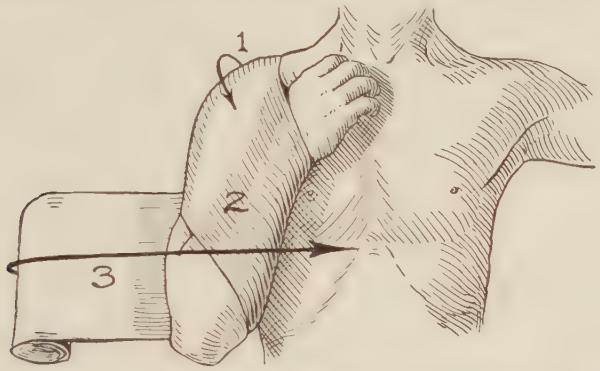


Fig. 373. The Lund swathe. Method of application to support the forearm in acute flexion.

handkerchief serve as tails for tying or pinning. By the manner of folding, a handkerchief bandage assumes the function of a four-tailed or three-tailed bandage, or a sling.

Lund swathe is used in the simpler types of fracture about the elbow-joint. It is made of a strip of muslin, 60 cm. wide and 5 to 6 meters long, folded four times along its narrow width, giving a strip $12\frac{1}{2}$ or 15 cm. wide and 5 or 6 meters long, which is then made into a roller

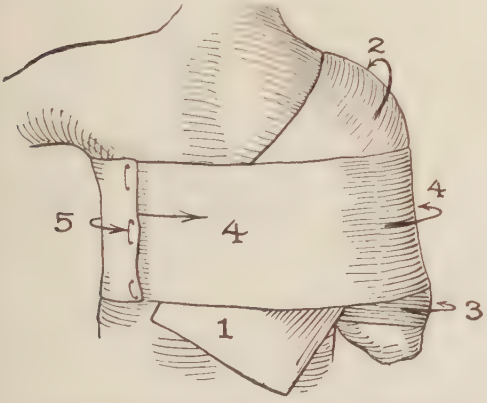


Fig. 374.—The Lund swathe. Completion of the bandage. The overlying layers should be pinned to each other.

Fig. 375.—Sling for the arm formed by a single oblique fold of a large square of muslin.

bandage. Beginning at the dorsal spine, the bandage is carried over the shoulder of the injured side, vertically downward, encircling the flexed elbow, and then horizontally around the chest until it reaches the injured arm, where the free

ends are pulled tight and pinned to the adjacent portions of the swathe, maintaining hyperflexion of the elbow.

Sling is a bandage used merely to support, but not necessarily to fix, a dependent part.

Elastic bandages are made of rubber or a fabric incorporating threads of rubber, or of cotton, linen, wool, or other material having an elastic weave. *Martin's bandage* is a roller of elastic, thin sheet-rubber.

Stiff, fixed, or **immovable bandages** include starched, plaster-of-Paris or gypsum, silicate of soda or water-glass, dextrin, flour, glue, chalk and gum, wax, or other material capable of hardening after application. The hardening substance is incorporated in the fabric used.

Fixed or *immovable bandages* usually consist of crinolin (30 mesh) or gauze, impregnated with dry anhydrous plaster-of-Paris (gypsum), made into a roller bandage and protected from moisture until used. For use, the bandage is submerged vertically in warm water to which, if rapid hardening is desired, salt has been added. As soon as the bandage is soft and thoroughly saturated, it is quickly applied.

Fig. 376.—Engel's plaster-of-Paris saw.

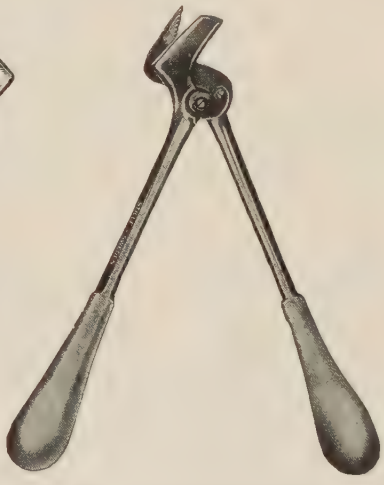


Fig. 377.—Heavy plaster cutting shears.

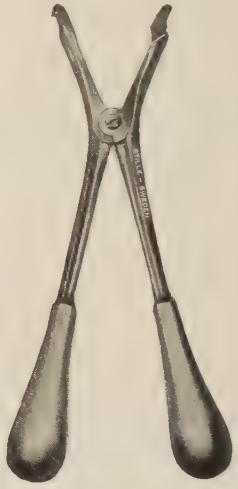


Fig. 378.—Plaster spreading forceps.

An underlying stocking, a section of stockinette, a soft bandage of canton flannel or woolen, or well-fitting drawers or undershirt is first applied. Bony prominences should be carefully padded by saddler's felt or other protective. The plaster bandage is applied as an ordinary spiral without reverses. The plaster becomes warm, and *sets* or hardens in about fifteen minutes. It may readily be slit, before it is thoroughly dry, with a sharp knife upon an incorporated strip of lead or zinc, or may be removed later by cutting with a small curved saw, a knife, special plaster shears, or an incorporated Gigli saw. The bandage may be reinforced or supported by ropes formed of twisted plaster-bandage.

Silicate, water-glass, or soluble glass bandage is made by applying a solution of silicate of soda or potassium by a brush to the layers of an applied gauze or muslin bandage. It requires twelve to twenty-four hours or more for evaporation and hardening, during which time the proper position of the limb must be maintained. It forms a light, strong bandage. It is softened by moisture, and hot water may be applied to aid the removal of the bandage.

Starch bandage, dextrin bandage, flour-paste bandage, and **glue-and-oxid-of-zinc bandage** are forms in which a thick, pasty or gluey mass of a hardening substance is rubbed and incorporated in the bandage during the application. These bandages are light, require twelve to forty-eight hours' exposure to the air for drying and hardening, and may be strengthened by incorporating pasteboard between the layers.

Splints are rigid, hinged, or flexible appliances used to give support to the bony framework or joints of the body.

Provisional or **emergency splints** may be fashioned of strips of wood or bark, umbrellas, canes, paste-board, or other simple contrivances, which are bandaged or tied to the part to be supported. The body may be used to splint the arm, as in Jones' position; the well leg, to splint the injured one.

Simple straight splint consists of a thin wooden board; padded upon one side and covered by a bandage; adapted to the side of the leg and body, it forms *Liston's straight splint;* to the medial side of the leg and foot—*Dupuytren's splint,* used for Pott's fracture.

Angular splints are made by uniting two boards at an angle appropriate for the condition to be treated. If the ends of the boards are united side to side, an *internal angular splint* is formed; if end to side, an *anterior angular splint* is formed.

Two Liston splints applied to opposite sides of the body, and united below the feet by a transverse piece of wood, form a *Travois splint.*

The **Bavarian splint** is formed by two pieces of flannel, folded once and sutured along the margins of the fold. Between the layers of each fold thick plaster-cream is introduced, and the splint molded to the part. The seam serves as a hinge in the removal of the splint.

Flexible coaptation splints usually consist of strips of wood arranged edge to edge, fastened by glue or other material to cloth or leather (*Gooch's splint*). A *simple coaptation splint* is made by fastening a number of wooden tongue-depressors edge to edge between two pieces of adhesive plaster.

Molded splints are usually formed of plaster-of-Paris roller bandage by folding the moistened bandage back and forth upon itself until it has the desired length, width, and thickness. This soft bandage is then immediately coapted and bound to the part by a suitable roller, and permitted to harden. Single, anterior and posterior, or lateral coaptation splints may be formed. They have the advantage of avoiding circular constriction, and of being readily removed and reapplied, facilitating the application of dressings. *Removable molded splints* are also made by cutting the fabric to the desired pattern, impregnating the formed layers with plaster, piling a sufficient number together to give the required thickness, then bandaging to the part after the plaster has been properly moistened.

Molded splints are also formed of metal, vulcanite, and other material. *Levis splints* are formed by thin, contoured, perforated metal. The poroplastic splint consists of sheet-felt impregnated with a hard waxy or resinous substance that softens on being heated, when it is molded to the part.

Wire splints may consist of very heavy wire or metal rod, as in the Thomas or the Hodgen splint, or of a coarse wire mesh.

The *Hammond wire splint* used for the lower jaw consists of a loop of wire contoured to the lingual and buccal sides of the necks of the teeth and fixed by fine wires passing between the teeth.

Braces are more permanent devices than splints; usually made of steel and leather, with or without hinges. They are used to stabilize, support, or reinforce a weakened defective part. Braces are applied to the arm, hip, knee, ankle, spine, and neck.

To permit extension or movement of joints, two boards may be hinged together with (*Stromeyer's splint*) or without a turn-buckle to modify the angle.

CHAPTER XXVI

GENERAL ANESTHESIA

Anesthesia is the absence of sensation.

Historical.—The ancients produced a degree of surgical anesthesia by administering preparations of poppy, and mandragora (*morphin, codein, hyoscin, hyoscyamin*). Before 1842 surgeons obtunded sensation before operating by giving alcoholics and opiates, by producing syncope through phlebotomy (Wardrop, 1827), or ischemia by arterial compression. Muscular relaxation, to facilitate the reduction of dislocations or other manipulations, was obtained by the use of alcoholics, relaxants, and emetics (*tartar emetic, tobacco enemas*).

Crawford W. Long of Georgia was the first to use *ether* for an operation (1842). Horace Wells of Hartford, Conn., extracted teeth under *nitrous oxid* in 1844. William T. G. Morton, a dentist and medical student, following the advice of his preceptor (Charles Jackson), experimented with ether, and gave the first successful public demonstration of surgical anesthesia in the Massachusetts General Hospital, October 16, 1846. In 1847 Sir James Y. Simpson of Edinburgh, after experimenting on himself and friends, introduced *chloroform* as an anesthetic.

Cocain, discovered by Gaedeke in 1855, was introduced by Carl Koller as a local anesthetic in ophthalmology in 1884.

Spinal anesthesia, suggested by the experiments of J. Leonard Corning of New York in 1884, was introduced into surgical practice by August Bier of Bonn, Germany, in 1898, after deliberate experiments on his own person. Bier's method with cocain was widely tried, but soon abandoned. In 1904 it was revived with the discovery of the synthetic local anesthetic *stovain*, by Forneau. Later the less toxic local anesthetic *novocain* (*procain, neocain*) was discovered by Einhorn.

Surgical anesthesia is the term suggested by Oliver Wendell Holmes to indicate the absence of sensation deliberately produced by a suitable agent or anesthetic. Even though the patient is unconscious of sensation, harmful impressions may register in the cerebral and spinal centers, as shown by changes in blood-pressure and other reactions; hence, Crile has proposed the term "anoci-association" or "anociation" for a psychic and sensory anesthesia, so perfect that noxious or harmful impressions are prevented from reaching the brain.

Anesthesia is tested chiefly by the *analgesia*, or loss of pain sense, but complete anesthesia includes the loss of all sensation, including pain, thermal, tactile, position, and pressure sense. For satisfactory surgical anesthesia motor paralysis or muscular relaxation is often essential, and an associated state of unconsciousness frequently desirable.

Definitions.—**General anesthesia** is loss of sensation of all parts of the body. It is divided, according to the point of entrance of the drug employed, into: (1) *Inhalation* or *pulmonary.* (2) *Rectal* or *colonic.* (3) *Gastric.* (4) *Venous.* (5) *Arterial.* (6) *Hypodermic* or *narcotic anesthesia.*

Regional or **infiltration anesthesia** is loss of sensation of a part of the body, produced through arrest of conduction in nerves by the injection or local application of a drug (*local anesthetic*). In a restricted sense, *regional anesthesia* is divided into: (1) *Conduction anesthesia*, where the conducting nervous pathway is blocked by the drug, and (2) *local anesthesia*, where the peripheral nerve-endings are obtunded by a local application or injection.

Indications.—Anesthetics are used: (1) *To relieve local or general pain* that cannot be relieved by milder measures, such as that from operation, childbirth, renal or biliary colic. (2) *To produce unconsciousness* in a patient overwhelmed by fear, terror, or mania, particularly during the performance of operation or during parturition. (3) *To cause muscular relaxation*, as in the reduction of fractures or dislocations, in precipitate labor, or for the examination of pelvic and abdominal organs. (4) *To relieve violent spasms* or *convulsions*, as in eclampsia, tetanus, insanity, and other conditions. (5) *For a therapeutic* or *psychic effect* on the neurotic, hysterical, or the malingerer. (6) *To diagnose the presence of organic* from functional, or assumed disease.

Physiology.—General anesthetics are solvents of fats and, according to Meyer Overton, after circulating in the blood enter into a loose physiochemical combination with vitally important lipoids in the cells of the central nervous system, so changing the constituents as to arrest the power of reception and conduction. Fat-solvents diffusible in oxygen tend to have a narcotic action on living protoplasm.

The following conditions, frequently observed in general anesthesia, are important:

Apnea, the cessation of breathing, leads to asphyxia, with an accumulation of carbon dioxid in the blood, primary stimulation of the respiratory and cardiac centers in medulla, acidosis, cyanosis, and, finally, paralysis of the centers and death.

Acapnia, a condition of diminished carbon dioxid in the blood, may be produced by overbreathing. Henderson caused shock by overventilation of the lungs, and has suggested the use of carbon dioxid during anesthesia as a respiratory stimulant.

Hypercapnia is an excess of carbon dixoid in the blood. Up to 35 per cent. of carbon dioxid in the inspired air stimulates respiration; 22 per cent. increases blood-pressure. Concentration above these points depresses both circulation and respiration. The acidosis of asphyxia does the tissues great harm.

Anoxemia, deficient oxygen-content of the blood, usually accompanies hypercapnia, and is an important factor in the damage to the cells.

Acidosis in Anesthesia.—The *acid-base equilibrium* of the body under normal circumstances is very stable. Carbon dioxid has an acid complement, and in the blood is neutralized by combination with alkali. The excess of alkali for this purpose is termed the "alkali reserve," and is estimated by the determination of the carbon dioxid in the alveolar air, or the capacity of the blood-serum to combine with carbon dioxid. The acid-base equilibrium is maintained by: (1) Elimination of carbon dioxid by the lungs. (2) Excretion of acid salts by the kidneys. (3) Presence of buffer substances, such as bicarbonates, phosphates, and phosphoproteins, in the blood. (4) Production of ammonia at the expense of urea. (5) The influence of oxygenation or barometric pressure.

The blood-plasma carbon-dioxid *combining-power* is normally 50 to 65 volumes per cent.; at 40 per cent. the condition is serious, below 30 per cent. the patient is in danger.

Ether produces immediate and marked *fall in the blood* PH and *bicarbonate content*, leading, if sufficiently prolonged, to an uncompensated acidosis (not due to ketone bodies or lactic acid) in from 15 to 20 per cent. of the cases. The protection of the patient depends upon the supply of alkali, such as sodium bicarbonate, ammonia, or less easily mobilized bases, such as calcium and magnesium. Prolonged etherization favors the production of lactic and other non-volatile acids not easily neutralized.

Ketosis may develop several hours after withdrawal of ether from deranged carbohydrate metabolism, due to the depressing action of ether on the insulin secretion.

Nitrous oxid-oxygen causes some *anoxemia*, an initial increase in PH, inconstant changes of carbon dioxid coefficient, but not as marked as from ether. As there is decreased anoxemia, the acidosis of ethylene-oxygen is less than after nitrous oxid-oxygen. In anoxemia there is an initial mobilization of blood alkali, followed by gradual tendency toward an uncompensated alkali deficit. Even without anoxemia the PH and carbon dioxid coefficient gradually fall below normal limits after forty minutes of anesthesia.

Local anesthetics have little effect of the blood-reactions except in very large doses.

With ether acidosis and the increase in hydrogen-ion concentration the colloids of the cell absorb water and the urinary output decreases with added poisoning. In diabetes the acidosis or ketosis is aggravated by ether. In jaundice the liver still further loses its protein detoxicating power. In elderly patients the acid-base equilibrium of the blood is less stable than in younger persons, and with the reduction in urea formation, albumin, casts, and diacetic acid appear.

Symptoms of acidosis vary from fatigue, nausea, vomiting, and gas-pains to coma and death. Conditions favoring uncompensated acidosis include extreme age, impaired kidney function, exhausting diseases, prolonged sepsis, hemorrhage, preoperative shock, the duration, depth, and toxicity of anesthesia. In shock there is always an uncompensated acidosis. If the patient shows a low bicarbonate content before operation he should have the benefit of alkalinization with sodium bicarbonate or other alkali.

The blood-concentration produced by ether may be relieved by the preanesthetic administration of water or hypotonic salt solution. The detoxicating action of the liver is fortified by a supply of glucose.

Pulmonary complications are increased by the intratracheal administration of ether and, perhaps, in local anesthesia from emboli due to the traumatism of tissues and veins.

Atelectasis of the lungs may be followed by hypostatic congestion and pneumonia. *Bronchopneumonia* is most serious, most frequent, and is also influenced by season, chilling during or after operation, advanced age, duration of anesthesia, and pre-existing respiratory infection.

Gastro-intestinal.—After ether or chloroform anesthesia the stomach remains relaxed, the small intestines show exaggerated peristalsis, the colon may

become spastic, with functional obstruction favoring an accumulation of gas and fluid above the level, with so-called "gas-pain." This does not occur after ethylene-oxygen, as peristalsis ceases and the segmental contractions are diminished for an hour or longer.

Moot's Rule: The pulse pressure is an indication of cardiac strength, and must be sufficiently high to compensate for a deficient kidney function. The addition of fluids is useless if the pressure is insufficient to cause elimination by the kidneys.

The **danger of an anesthetic** depends on the patient, the drug, and the anesthetist. In shock, collapse, asthenia, starvation, all anesthetics are dangerous, except forms of local infiltration. In prolonged operations, ethyl chlorid, chloroform, nitrous oxid-oxygen, ether, ethylene-oxygen are dangerous in the order given. Nitrous oxid is dangerous in arteriosclerosis; ether in acute respiratory disease; chloroform in acidosis. The anesthetist, not thoroughly trained or skilful, often will permit a continued very harmful hypercapnia, and will have about 1 death in about 500 administrations for *ether;* 1 in 300 or 400 for *ethyl chlorid, chloroform, nitrous oxid-oxygen;* 1 in 250 for spinal anesthesia.* The statistics, often quoted, of 1 death to 3000 administrations of chloroform, 1 to 15,000 for ether, do not apply to the average surgical practice.

For safety in anesthesia, expert anesthetists and careful selection and preoperative study of patients are essential. It is also very important to select the anesthetic least harmful, in relation to the operation and condition of the patient.

Examination preliminary to the administration of a general anesthetic should search for all factors that might render the anesthetic or the operation dangerous.

Circulatory System.—The size and location of the heart, the presence or absence of adventitious sounds, and indications of possible circulatory insufficiency—such as arhythmia, pallor, cyanosis, edema, cough, bronchopulmonary râles, and dulness of the base, should carefully be noted. The pulse rate and blood-pressure should be recorded, and the time the patient is able to hold his breath (*Stange's test*): Myocardial insufficiency is suggested if the patient is not able to hold his breath longer than thirty seconds. Coronary disease may be feared if rest relieves the retrosternal pain caused by exertion. Edema of the dependent parts of the body, enlargement of the liver from passive congestion; ascites, edema or dulness at the base of the lungs; cyanosis, dyspnea, low pulse-pressure, evidence of heart-block, fibrillation, mitral stenosis, and other conditions associated with auricular thrombosis usually contraindicate general anesthesia. With forms of cardiac disease usually associated with auricular thrombosis, complete rest in bed for three weeks before operation (to fix the blood-clot) is desirable, and lipoid-solving general anesthetics, such as ether, should be avoided. Inhalation anesthesia should be avoided also in vegetative endocarditis, coronary obstruction, advanced aortic disease, aortic aneurysm. Loud heart-murmurs from compensated valvular insufficiencies do not contraindicate anesthesia.

Blood-pressure and *pulse rate* are so important in indicating the condition of the patient that readings should be recorded every five minutes during general

* Based on personal observations collected from a number of surgeons.

or spinal anesthesia. The following guide is useful during general anesthesia: (1) *Safe*—15 per cent. increase in pulse rate, without increase in blood-pressure; or 10 per cent. decrease in blood-pressure, without a decrease in pulse rate. (2) *Dangerous*—25 per cent. increase in pulse rate, plus 10 to 25 per cent. decrease in blood-pressure. (3) *Shock*—a pulse rate of 100 and rising, with systolic blood-pressure progressively falling to 80 mm. or lower during the operation. Without effective remedial measures death is almost inevitable in twenty-four to seventy-two hours. This guide discloses the onset of shock at least twenty minutes earlier than it is indicated in any other way (McKesson and the committee of the International Anesthesia Research Society).

The systolic pressure alone is of limited value, the diastolic pressure alone is of more value than the systolic pressure alone. The pressure ratio is the essential factor, and offers the earliest danger-signal. The pressures may be modified by the psychical and emotional state of the patient, the position of the patient (as the extreme Trendelenburg position), an excess of anesthetic, or operative traumatism.

Moot's Index for Operability.—Pulse pressure divided by diastolic pressure equals the *pressure ratio per cent.* or index for operability. Fifty per cent. being normal, 75 per cent. high, 25 per cent. low. If the pulse ratio is high or low, there is reason to apprehend danger; if the pressure ratio lies between 40 and 60 per cent., the patient is safely operable; if between 40 and 25 per cent., or 60 and 75 per cent., probably operable; but if above 75 or below 25 per cent., probably inoperable.

Energy Index.—The systolic plus the diastolic pressure times the pulse rate equals the energy index. Numerals of thousands only are used as an index. In this index the systolic pressure and pulse rate show heart capacity; and the diastolic end-resistance in terms of mm. of Hg., energy expended for each minute. If the energy index lies between twelve and eighteen (12,000 to 18,000), the patient is safely operable; if between sixteen and twenty-four, or twelve and six, probably operable; and if above twenty-four or below six probably inoperable. *Example:* The systolic 120 plus diastolic 80 times the pulse rate 72 equals 14,400 mm. of Hg. per minute, or an index of 14.4, which is safe.

Respiratory Tract.—Gum, tobacco, plates, or other foreign bodies in the mouth should be removed before a general anesthetic is given. Purulent discharge from the nose, mouth, or pharynx may be inhaled during general anesthesia, causing serious infection of the lungs. Sinusitis, purulent tonsillitis, abscesses or fistulæ about the teeth or mouth should be corrected, or other anesthesia substituted for the inhalation anesthesia. Apart from aspirated foreign bodies, tonsillectomy has been the most common cause of pulmonary abscess during recent years. *Acute respiratory infections*, such as acute bronchitis, rhinitis, pharyngitis, tonsillitis, asthma, and pneumonia, contraindicate the administration of ether or chloroform, as does empyema. In *pneumonia* an exacerbation, not infrequently fatal, usually follows the use of ether. In *very chronic forms of bronchitis* the stimulating effect of ether on the bronchi is usually harmless. In *pulmonary tuberculosis* the use of ether or an apparatus which involves irritation or strain on the respiratory organs is to be avoided. Chloroform and ethylene, carefully administered during pulmonary tuberculosis, do little harm.

Ether is particularly irritating to the respiratory tract; nitrous oxid and, especially, ethylene produce no local irritation, but their administration involves respiratory strain, particularly the more stimulating nitrous oxid. With disease of the respiratory tract, spinal, local, or narcotic anesthesia is safer; but, if inhalation anesthesia is desired, chloroform is to be preferred to ether; nitrous oxid-oxygen to chloroform; and ethylene to nitrous oxid. Ethylene gives quieter respirations with less anoxemia, than does nitrous oxid.

Digestive Tract.—The stomach should be emptied before inhalation anesthesia. Food in the stomach increases nausea and vomiting, and may be vomited and inhaled, causing suffocation, or *inhalation pneumonia*. No food should be given within six hours of the time of operation and, in the case of *pyloric stenosis* or *intestinal obstruction*, food retained in the stomach should be removed by lavage previous to the administration of the anesthetic. Abdominal distention may seriously interfere with inhalation anesthesia by pressing the diaphragm upward. It is desirable also to have the lower intestinal tract emptied by laxative or enema.

Ductless Glands.—In children the most common cause of sudden death during general anesthesia is *status lymphaticus*, or enlargement of the thymus. A child with dulness over the manubrium, fulness of the episternal notch, enlarged cervical lymph-nodes, or one with a history of thymic asthma or stridor should not be given a general anesthetic until, by Roentgen examination and treatment, any enlargement of the thymus has been detected and reduced. A single Roentgen treatment often suffices. *Exophthalmic goiter*, or *toxic adenoma* of the thyroid, contraindicates the use of ether, chloroform, or other deep inhalation anesthetics, and epinephrin. Ethylene, carried to the stage of analgesia, with the associated use of local anesthesia, is preferable to nitrous oxid-oxygen.

Brain.—On account of the congestion and swelling produced, nitrous oxid should not be used for operations upon the brain or spinal cord. Ether also causes engorgement of the brain, and should be used with great care, best as a vapor mixed with oxygen. Chloroform does not produce the cerebral engorgement of ether, but is a dangerous drug, poorly adapted to the constrained position in which the patient may be placed, or to a very prolonged operation. Ethylene has advantages if the apparatus is not in the way of the surgeon. Local anesthesia is the safest anesthetic for operations on the brain. Distention of the lateral ventricles may cause pressure or edema involving the bulb, with cessation of respiration and circulation during anesthesia. If this occurs, the patient should be instantly relieved by a ventricular tap and artificial respiration.

Urinary System.—Both chloroform and ether, particularly the former, are irritating to the kidneys and should not be used in serious degenerative forms of *nephritis*. Local anesthesia, spinal anesthesia, ethylene, and nitrous oxid are to be preferred in the order given.

Liver.—In *acute yellow atrophy* of the liver, chloroform, ether, or large doses of narcotics should not be used, and they should be avoided in advanced *fatty change*, *jaundice*, or *other serious degeneration* of the organ. As in disease of the kidneys, local or spinal anesthesia or ethylene is to be preferred. The anoxemia of nitrous oxid is dangerous.

Diabetes.—Chloroform or ether are to be avoided, also nitrous oxid on (account of the cyanosis and acidosis associated) except to the stage of analgesia. Local infiltration may be followed by necrosis and infection from the diminished circulation and lack of resistance of the tissues. Spinal or conduction anesthesia is preferred, although inhalation anesthesia by ethylene, not carried to the point of cyanosis, is permissible.

Blood.—Ether or chloroform are objectionable with hemoglobin percentages below 60, and contraindicated by percentages below 30. Local anesthesia or ethylene are to be used in case of extreme anemia. A preliminary transfusion of blood is often desirable.

Shock.—Local anesthesia by procain-adrenalin is the safest anesthesia in shock. A very light nitrous-oxid or ethylene analgesia may, at times, be associated with advantage. In general, safety goes with the shortest, lightest, least disturbing anesthesia and the freest elimination.

Precautions During Anesthesia.—During the period of excitation the patient may struggle, fight, or jump from the table, with possible injury to himself or to the bystanders. Alcoholics and powerful robust individuals should be strapped to the table before the administration of the anesthetic, with care that the restraint does not interfere with the respiration or circulation. The patient is protected from ether or chloroform burns by coating the face with petrolatum, and the eyes by a layer of thin gutta-percha tissue, covered by a cotton pad wrung out of saturated boric acid solution. While this prevents the observance of the eye reflexes, a skilled anesthetist is safely guided by the character of the respirations, color of the skin, and the pulse. Should ether or chloroform accidentally enter, the eye should be irrigated with boric acid solution, and 2 drops of castor oil instilled. Chilling of the patient, with subsequent secondary pulmonary or other complications, results from exposure, or contact of the patient's body with wet sheets, rubber or metal surfaces on the operating table. The patient should be well blanketed, and kept warm throughout the period of the anesthesia by hot-water bottles or pads; but great care should be exercised, as many serious burns have resulted from improperly protected hot-water bottles and heating pads, applied to the anesthetized patient. Electric heating pads, when moistened, may give off steam. Sacro-iliac strain and other spinal symptoms may follow lack of sufficient padding, or strained, unusual positions on the operating table.

The **anesthetist** should personally be clean and not have come from attendance on communicable disease, especially erysipelas. He should be free from ear, nose, throat, or eye infection, and be perfectly familiar with the operating table and all its movements and possibilities. He should have available for immediate use, and understand thoroughly, the emergency set for subcutaneous or intravenous administration of salt solution, adrenalin, and other restoratives and also tongue forceps, mouth gag, swabs or aspirator, emesis basin. He should cleanse his hands before each inhalation anesthesia. The patient's life often depends on the promptness and intelligence of the anesthetist. Danger should be anticipated, and the patient protected by prophylactic treatment.

Preparation of Patient for the Anesthetic.—Prolonged or exhausting diagnostic or other measures should be avoided immediately before anesthesia.

Hemorrhage, dehydration, asthenia, acidosis, jaundice, and degeneration of parenchymatous organs should be treated as described in Chapter XXVIII. An efficient but not exhausting laxative the day before operation, and an enema two or three hours before the time of operation are desirable. After the laxative, all food is to be avoided, although a small quantity of clear liquid, such as plain tea, water, or clear broth, may often be given up to six hours of the time of operation. The bladder should be emptied immediately before the operation by catheter, if necessary. The hair should be protected from vomitus and other fluids by a suitable cap. Loose teeth, plates, gum, tobacco, and other foreign bodies should be removed from the mouth. The neck, chest, and abdomen should be released from tight clothing or other constriction, and the arms should not be held above the head (*brachial palsy*) or permitted to rest on the edge of the table (*musculospiral palsy*) during the anesthesia.

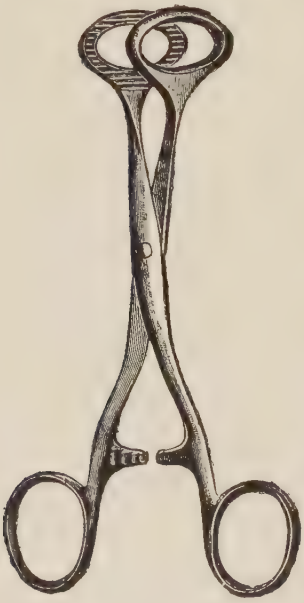


Fig. 379.—Collin's tongue-holding forceps.

After the operation the patient should be carefully watched for secondary hemorrhage, suffocation from the falling back of the tongue, the inhalation of foreign bodies or vomitus, and should be guarded from burns by hot-water bottles, undesirable movements, such as falling out of bed, and the disarrangement of dressings or splints. If not contraindicated, lavage of the stomach before the patient leaves the operating room aids elimination, and reduces postoperative nausea and vomiting. After consciousness returns, the mouth may be washed frequently from the first, but liquids by stomach are usually withheld until nausea has subsided. For persistent nausea, to facilitate elimination by emptying the stomach, the patient may be given two or three cups of hot water, each containing 1 gm. of sodium bicarbonate. After the use of chloroform, vinegar may be inhaled. Elimination also may be aided, and fluids and fuel supplied as needed, by rectal, subcutaneous, or intravenous injections.

ETHER

Ether (ethyl oxid, $(C_2H_5)_2O$) is a very volatile, inflammable, explosive liquid, with a rather disagreeable pungent odor. The vapor is heavier than air. It acts more slowly than other general anesthetics, and may be used with less skill and a greater margin of safety. Consequently, it is the most widely used anesthetic.

Contraindications.—Acute respiratory infections are aggravated, even to severe pneumonia, by the inhalation of ether. Chronic bronchitis may be improved by the stimulating action of ether. Etherization usually is unwise in: (1) Pulmonary tuberculosis. (2) Renal disease. (3) Diabetes. (4) Acidosis. (5) Ophthalmia. (6) Brain tumors. (7) In cranial operations ether may cause undesirable congestion, but it is successfully used by the skilled. (8) It is

less adapatable, though frequently used, for infants, young children, and the aged.

Physiologic Action.—Ether *stimulates the respiratory mucous membranes* to increased secretion. The respiratory center in the medulla is first stimulated, causing rapid, full respirations; followed by depression, with slow, shallow breathing. The respirations offer the best guide as to the degree of anesthesia. The *heart is stimulated* and accelerated, and there is a slight early rise in blood-pressure, succeeded by vasodilatation, slow full pulse, and finally gradual fall in blood-pressure with a terminal rapid, weak pulse. Unless there is serious cardiac disease, respiratory arrest precedes that of the heart. Large doses cause hemolysis and capillary hemorrhage into the stomach, with black or *coffee-ground vomit*. *Parenchymatous changes* occur in the liver and kidneys, the excretion of urine and nitrogen is diminished; the urinary chlorids are increased, and albumin, sugar, cylindroids, casts, excess of leukocytes, and acetone are often found in the urine after profound etherization.

Ether is largely eliminated within two hours through the lungs, kidneys, skin, and gastro-intestinal tract, but complete elimination may require two or three days.

Stages of Anesthesia.—First Stage.—*Stimulation* (first two to five minutes): The patient is conscious, but mentally confused; with stimulation of circulation and respiration, dilated mobile pupils, and suffocation and rigidity if the ether vapor is too concentrated.

Second Stage.—*Excitement:* The patient is unconscious, but delirious, with an excess of saliva and mucus in the respiratory tract; a sweating, red, warm skin; a rapid, full pulse. The delirium is marked by crying, shouting, laughing, struggling, fighting, rigidity, muscular contractions, tremor, periods of apnea, cyanosis. The stage of excitement is more marked in the sthenic and alcoholic.

Third Stage.—*Surgical Anesthesia:* Is shown by even, regular respirations, snoring, muscular relaxation, pink color, pupils that react and are of moderate size, retained lid-reflex, and absent coughing-reflex and phonation.

Fourth Stage.—*Paralysis* is due to *overdosage*. The respirations are shallow, weak, irregular; the face suffused and dusky; the pulse full and strong from cyanosis, becoming soft, rapid, irregular; the pupils are widely dilated and fixed, the eyelids separated. Convulsive movements occur at times.

Ether Percentage Required.—The ether percentage (by weight) necessary in the inspired air has been shown by Connell to rise rapidly to 30 to 45 per cent. in the preliminary stage; the higher percentages being required in the young, robust, and alcoholic, and the lower in children and in weak or senile adults. After the first few minutes (or the stage of excitation) the percentage required falls to about 26 per cent., and with complete surgical relaxation is gradually reduced to 15 per cent., which percentage may be used for continuous anesthesia. Sufficient saturation of blood for full surgical anesthesia requires about two minutes for each liter of circulating blood, or six minutes for a child and ten to twelve minutes for an adult. The entire body is not brought to *surgical saturation*, or an ether tension of about 48 mm., until forty to sixty minutes have elapsed. As *desaturation* is slower than saturation, and as anesthesia is more easily deepened than diminished, the anesthetist, after reaching the third stage, reduces

the percentage to the lowest point compatible with relaxation. As 7 per cent. of ether vapor causes irritation and cough in the conscious patient, the anesthetist should begin with only 3 to 6 per cent., rapidly increase to 30 to 45 per cent. as tolerance and unconsciousness appear, and finally reduce to about 15 per cent. for maintenance of deep anesthesia. Timing the period of desaturation, the anesthetist discontinues the induction before the operation is quite completed, so that the patient awakes soon after the operation is finished.

Technic.—Open Drop Method.—It is most important to obtain and not to destroy the patient's confidence and co-operation. A patient who is frightened, strangled, struggling during the first stage will usually have a more dangerous and difficult anesthesia than the patient with an easy induction.

Having protected the patient's eyes and face to prevent ether burns, 8 to 12 layers of gauze are held 3 cm. above the patient's nose. The patient is encouraged to breathe easily and naturally through the nose, as ether is dropped on the gauze at the rate of about 2 drops each second. The admonitions "blow it away," "take deep breaths," or "count" are harmful (except for children), as they cause the patient to breathe irregularly, and prevent an easy progressive induction. Oil of bitter orange peel in alcohol, as suggested by Gwathmey, may first be dropped upon the gauze to disguise the odor of ether. Continuous soothing or diverting conversation should be used by the anesthetist until the patient is asleep. As the patient becomes mentally dulled and the pharyngeal reflex is reduced, the gauze is brought down to the patient's face with added layers and surrounded by wet or dry towels to more fully exclude the air. The ether is then dropped continuously and more rapidly, so that the gauze is constantly saturated, but not dripping. If the patient is resistant, additional layers of gauze are added to hold larger quantities of ether. Nausea and excitation are overcome by increasing the percentage of ether, so as to shorten the stage of excitation. Vomiting is treated by turning the patient's face to the side, and evacuating mucus and gastric contents with the least possible interruption of the inhalation. Persistent vomiting usually indicates an irregular and non-progressive induction. In the *third stage* the respirations become deep, full, and rapid, and the ether intake is thereby greatly increased. The amount is then carefully reduced to prevent overdosage until the anesthetist has determined the smallest number of drops, given every five or ten seconds, which will maintain sufficient relaxation. The lightest anesthesia compatible with the particular operative procedure is used. Complete muscular relaxation is produced only at and for the time it is required. Even with extensive abdominal operations, slight subconscious movements of the hands and feet often may be permitted, an indication that the patient is not profoundly under the ether.

Emergence: A faint expiratory moan or grunt, with a deep inspiration and change in respiratory rhythm, soon to be followed by gulping or nausea, vomiting, return of reflexes, and muscular movements, indicates return to consciousness. Irregular anesthesia, recurrent nausea and troublesome movements, alternating with noisy, obstructed breathing, loud mucous râles, cyanosis, and stertorous respirations usually characterize a careless or incompetent anesthetist. Skill is shown by a pleasant, easy, and often rapid inductance, even quiet

anesthesia, not too profound, yet sufficient relaxation for each step of the particular operation, early emergence after the completion of the operation, and the small amount of anesthetic used.

Danger signs: (1) *Cyanosis*, characterized in the early stages by a slow, full pulse, is always dangerous and should never be permitted. (2) *Shallow gasping, or irregular respirations with sudden respiratory collapse*, in the third stage are ominous, as are (3) *an ascending pulse rate* with decreasing respiratory rate and pallor, (4) *widely dilated fixed pupils*, (5) *sudden increase (cyanosis) or fall in blood-pressure*, and (6) *weak, rapid, or irregular pulse*. With any of these symptoms, the anesthetic should be discontinued until the patient is known to be in a safe condition. Especially dangerous is the attempt to relieve the muscular rigidity, that goes with cyanosis, by giving more anesthetic. The possibility of laryngeal or tracheal obstruction from inhaled foreign bodies or vomitus should never be forgotten. Straining and obstructive breathing, with much mucus and loud râles, should not be tolerated. The air-way should be kept free, and the respiratory mechanism guarded against undue strain.

Fig. 381.—Denhardt's mouth-gag with anesthetic tube for vapor. For use in operations about the air-passages.

Postanesthetic complications affecting the respiratory tract: After etherization, 2 per cent. of all patients have some form of pulmonary complication; 4 per cent. after abdominal operations; and 8 per cent. after upper abdominal operations (Cutler and Hunt). Infection may enter the lungs through the air-passages,

Fig. 380.—Connell's air-way or breathing tube. Introduced in the mouth to prevent suffocation.

blood-stream, or lymphatics. Ether irritates, but does not cause definite inflammation of the tracheobronchial tract. With profound anesthesia and loss of the cough-reflex, the fluids of the mouth and pharynx (including vomitus) enter the lungs and may pass to the finest bronchi. Protective factors are the resistance of patient, the preservation of the pharyngeal and cough-reflexes, and the action of cilia. Aspiration is to be feared during stridor, vomiting, and struggling. It may occur from failure to turn the head promptly to the side or to remove mucus or vomitus from the mouth or pharynx. There is increaesd danger with sinus and tonsillar infection, and less danger of aspiration with the patient in the Trendelenburg position which, however, may increase the strain

in respiration and circulation. In temperate climates pneumonia after ether is least common in July and most common in February.

Special Methods of Etherization.—**Semiclosed, Closed, and Rebreathing Methods.**—In the *semiclosed method*, a towel-covered paper cone or cylinder containing gauze may be used; for the *closed method*, the Clover inhaler and its modifications. The excess of carbon dioxid stimulates the respiratory and circulatory centers. For *rebreathing* the apparatus has a connecting bag to collect and return the exhaled vapor. Although these methods reduce the amount of ether necessary, the injurious effects of the anesthetic are increased, especially if an acute infection of respiratory tract is present or if rebreathing is carried to excess.

Vapor Method.—Air, oxygen, or other gas impregnated with more or less ether vapor is carried to the patient. A foot bellows, a pump, or gas delivered from a tank under pressure is used. The vapor may enter: (1) A mask or face-piece; (2) the *mouth* through suitable tubes; (3) the *pharynx* through a nasal inhaler, or a tube introduced through the nostrils or mouth; (4) the *trachea* by a tracheal tube, or (5) the *rectum* by a rectal tube. The vapor is more effective if warmed. The vapor method ensures a more even and accurate narcosis, with less mucus and irritation of the respiratory tract.

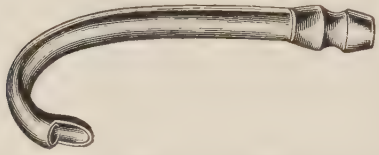


Fig. 382.—Gwathmey's hook-shaped tube for introducing anesthetic vapor into the mouth.

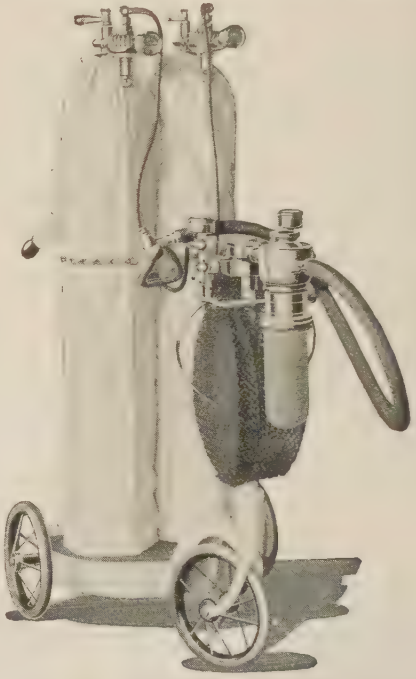


Fig. 383.—McKesson gas machine for anesthesia with nitrous oxid, ethylene, and ether in association with oxygen or carbon dioxid.

Ether rausch is largely used in Germany, and to a limited extent in this country, for operations and surgical procedures not requiring relaxation or anesthesia of over two minutes' time. It is to be avoided in children, in the asthenic, and in the presence of pulmonary or cardiac disease.

A large mask or cone, containing a large pad of gauze wet with 60 c.c. of ether, covered with impermeable material, and so surrounded by wet towels as to exclude air, is used. The patient is warned to endure the suffocating effect, keep the arm elevated, and breathe rapidly and deeply. After ten to fifteen deep inspirations, the arm falls, the mask is removed, and the operation started. The associated and after-effects—cyanosis, nausea, and delirium—are usually very transient, and in twenty to thirty minutes after the operation the patient may walk from the operating room.

Klapp's Method (1917).—Ether or chloroform is administered after constricting the extremities by elastic bands placed close to the body. The anesthetic is not carried to the extremities until the bands are released. This reduces the amount of anesthetic necessary, and increases the rapidity of emergence from the drug. If unfavorable symptoms develop, the anesthetic is withdrawn and one or more of the bands loosened. With disease of the veins or arteries, thrombosis or other complication may follow the use of the method, and in any case the constricting bands should not be left in place longer than one hour.

Sequence Anesthesia.—To avoid the rather prolonged and disagreeable induction period of ether, a preliminary narcosis may be obtained by nitrous-oxid-oxygen, ethyl chlorid, somnoform, or chloroform; ether being substituted as soon as the patient is unconscious. It is best carried out with nitrous-oxid-oxygen, a special apparatus being desirable.

Combined Anesthesia.—In ether anesthesia a little chloroform may be added to increase the relaxation, or to reduce the irritation of the respiratory organs. Ether anesthesia is frequently combined with nitrous oxid or ethylene anesthesia to produce muscular relaxation. Ether may be combined with spinal or local anesthesia to intensify the effect, produce unconsciousness, or to antidote a fall in blood-pressure. Narcotics and somnifacient drugs (morphin, atropin, or hyoscin) are often injected before the administration of nitrous-oxid-oxygen, ethylene, ether, or spinal anesthesia, to aid narcosis and produce mental tranquility.

Intratracheal Insufflation (Meltzer and Auer, 1909).—The patient is first anesthetized by the open ether or other method. A silk woven elastic catheter with a smooth lateral or terminal opening is then introduced by the finger, special cannula, or Jackson's speculum to the bifurcation of the trachea, withdrawn 2 to 3 cm., and fastened in position. The diameter of the catheter should be about one-half that of the trachea, or size 24 F. for an adult. In an adult the distance from the incisor teeth to the end of the catheter is 26 to 27 cm. The vapor is introduced with a constant pressure of not over 20 mm. of Hg., and the stream should be momentarily interrupted three to six times a minute, to allow the lungs to partially collapse and to force out residual carbon dioxid (ventilation of the lungs). From leakage the pressure in the alveoli does not exceed 8 mm. of mercury. A special apparatus is desirable. This method is useful in operations on the chest, as oxygenation continues irrespective of the patient's respiratory movements. Death has followed the accidental entrance of pure ether into the tube.

Rectal Ether Anesthesia.—Pirogoff (1847) showed that ether vapor introduced into the rectum was rapidly absorbed, with the production of anesthesia. Tympany, tenesmus, bloody and mucous stools may result from the irritation produced. Gwathmey (in 1913) introduced *oil-ether colonic anesthesia*, based upon the rate of evaporation of ether from an oily mixture.

Contraindications: (1) Whenever ether is contraindicated *except* when the patient has merely been made ill by a previous administration. Here it may be given with impunity. It may also be given in bronchitis and asthma. (2) Pathologic conditions of the lower bowel, as colitis, hemorrhoids and fistula, that would lead to severe pain from the administration.

Technic.—Preparation of the patient: (1) A mild laxative, avoiding all purging. (2) Irrigation of the colon until the return is clear, three or four hours before operation.

Apparatus.—(1) A small catheter and funnel; (2) two small rectal tubes inserted side by side to flush and withdraw fluid.

Administration.—(1) One hour before operation there is given by rectum: Chlorbutanol (0.3 to 0.6 gm.) dissolved in ether (8 to 16 c.c.) and mixed with olive oil (8 to 16 c.c.). (2) One-half hour before operation: Morphin (0.0081 to 0.0162 gm.), atropin (0.000325 to 0.00065 gm.) by hypo.

(1) Mixture for adults: 1 ounce of 65 per cent. ether for each 20 pounds of body weight, or an average of olive oil 2 oz., ether 6 oz. (2) Mixture for weak anemic patients: Ether 55 to 65 per cent., oil 45 to 35 per cent. (3) Mixture for children: Ether-oil 50 per cent.

The patient should be in Sims' position. The catheter is well lubricated and inserted 4 inches within the rectum. The mixture is poured slowly into the funnel, at least five minutes being consumed. One ounce of the mixture is used for every 20 pounds of body weight, except for the obese. From ten to thirty minutes should elapse before the patient is moved. The rectal tube is clamped and left in, to enable the solution to be withdrawn at the end of the operation or when an excessive effect is noted. Unconsciousness appears in five to nineteen minutes, and surgical anesthesia in thirty to forty minutes. The patient must be watched constantly, and suffocation from dropping back of the tongue or jaw prevented. The anesthesia lasts two and a half to three hours. If insufficient, local or inhalation anesthesia is resorted to. If excessive, the residual mixture in the colon is drained away. As the ether reaches the centers through the portal circulation, rather than directly through the lungs, the effect upon the liver is to be considered.

Danger Signals.—(1) Loss of lid-reflex; (2) Stertor or embarrassed respiration; (3) approaching cyanosis. If any of the above signs appear, 2 or 3 ounces of the mixture are withdrawn immediately from the rectum. If the breathing is regular and reflexes active, the patient will be relaxed and in surgical narcosis.

Postoperative.—The colon should be immediately irrigated with cold soapsuds. One of the tubes should then be withdrawn from the rectum, and 2 to 4 ounces of olive oil and from 1 pint to 1 quart of cold water introduced. Slight irritation of the rectum or skin may follow; usually there is secondary nausea and occasionally the presence of albumin and casts in the urine.

Rectal Ether Analgesia in Childbirth.—This consists of one or more hypodermic injections of morphin and magnesium sulphate, followed by the introduction of the oil-ether mixture into the colon.

CHLOROFORM

Administration.—Chloroform is six times as powerful as ether, and is given well diluted with air by the open method, or as a vapor mixed with oxygen. A single layer of flannel, stockinette, or lint is used, which is held 3 to 5 cm. above the face by a wire frame (Esmarch's inhaler). One drop of chloroform, gradually increased to 5 or 10 drops, is given every ten seconds. The period of excitement is usually short and mild, except in alcoholics. With the third stage of surgical

anesthesia the pupils return to normal, the respirations become regular, the pulse slow, the blood-pressure lower, the face pale. The time of induction is three to six minutes, or about one-half that of ether. The maintenance dose of chloroform is about one-half that required for the induction. For safety the mask should be removed from the face every ten minutes for one or two respirations. With the patient well relaxed, the dose should be reduced from time to time to 3 drops every ten seconds. As the reflexes begin to return and the pulse increases in rate and volume, the dosage is again increased until relaxation returns. The chloroform concentration should not exceed 2 per cent.

Contrasted with ether, chloroform is less bulky, is not inflammable; has a sweetish, rather pleasant odor; acts more rapidly and agreeably; does not cause excess of saliva and mucus nor the same sense of suffocation, strangling, or pharnygeal or bronchial irritation or nausea, and does not leave an objectionable odor to the secretions.

Fig. 384. Esmarch's chloroform bottle and inhaler. The inhaler is covered by a single layer of flannel or stockinet.

Dangers.—Chloroform acts rapidly and powerfully, and alarming symptoms develop with great suddenness, so that constant supervision is necessary. Many deaths have occurred in the first stage, especially from reflex causes, as painful manipulations or even swabbing of the pharynx. Marked pallor, cyanosis, weak and irregular pulse, shallow or irregular respirations, and widely dilated pupils indicate danger. A gradual, regular, drop-by-drop anesthesia, with ample supply of air and avoidance of any operation during the first stage, is important.

Death usually follows a primary arrest of the respiration, but sudden cardiac arrest occurs in cardiac disease. From the tendency of chloroform to decompose, it should be sealed until used. Because of the circulatory depression, the upper part of the patient's body should not be raised during chloroform anesthesia. In contact with an open flame, chloroform vapor forms chlorin and other irritating, cough-producing compounds. It should not be used in serious heart disease, or in shock, acidosis, cyanosis, anasarca, status lymphaticus, or diabetes. Held in contact with the skin it causes more severe burns than ether.

Acid Intoxication.—Serious degeneration of the parenchymatous organs (notably the liver, kidneys, and heart) may follow chloroform and, to a lesser degree, ether, particularly in the obese, in children, or diabetics. The fat is broken down into acetone and diacetic acid, which may be noted on the breath, in the blood, and urine. There is persistent vomiting (often of black "coffee-ground" material from extravasated blood), with restlessness, delirium, coma, and possibly death. Elimination should be aided and the acidosis overcome by frequent lavage, by the use of large enemas containing glucose and sodium bicarbonate, and by the intravenous injection of 10 per cent. glucose in Fisher's solution.

NITROUS OXID

Nitrous oxid (N_2O), a colorless odorless gas, was discovered by Joseph Priestley in 1772, used by Horace Wells for extraction of teeth in 1844, and with oxygen by Andrews in 1868. It is supplied, compressed into liquid, in vanadium-steel cylinders which may split, but do not shatter on bursting. One ounce of liquid gas yields $3\frac{1}{3}$ gallons of gas. To avoid freezing the gas outlet should be above the level of the contained liquid. Only gas tested and free from carbon monoxid should be used.

Physiology.—The pure gas, when inhaled, produces cyanosis and asphyxia, with final paralysis of the respiratory center from absence of oxygenated blood. The blood is not altered; the gas, being in simple solution in the blood, is quickly released on contact with the air. The blood-pressure is increased markedly when asphyxia is produced, but only moderately by gas-oxygen properly administered. The brain and spinal cord are increased in bulk instead of being diminished as in asphyxia. Anesthesia is probably caused by a direct action of the gas on the cells of the central nervous system. The muscles become rigid and, if cyanosis is produced, tonic and clonic spasms (*opisthotonos*) may occur. Erotic hallucinations are present at times, which persist after return to consciousness, and in several instances have had a serious medicolegal import. From deep or prolonged narcosis, nausea, vomiting, involuntary micturition or defecation may occur. Death is due to asphyxia, the heart beating after respirations have ceased.

Action.—Complete anesthesia by nitrous oxid is produced in from thirty to sixty seconds when air and oxygen are excluded. The patient then becomes cyanotic, the face livid, the eyes protrude, convulsive movements shake the body, and, if the mask is removed, consciousness quickly followed by sensation returns in about one minute. This short period is sufficient for the extraction of teeth or other very transient operation. If air is not carefully excluded, anesthesia may be greatly delayed or fail to appear. This brief form of anesthesia, largely used by dentists, is very safe. Only occasionally is artificial respiration required, and usually there is no untoward effect.

Nitrous Oxid-oxygen.—With nitrous oxid-oxygen the induction is more prolonged. There is a *first stage* of *stimulation* with exhilaration or mirth, warmth in the lips, numbness of the limbs, and whirring or rumbling sensations in the ears, increasing in rapidity and intensity to loss of consciousness. Preceding the loss of consciousness there is analgesia, which may be maintained for long periods of time. With a nasal inhaler dentists use this stage for prolonged painful manipulations, the patient being benumbed, yet conscious and able to converse.

The *second stage* is one of *excitement* with incoördinate sounds and movements, and evidence of intoxication. During this period erotic dreams may occur. The respirations and pulse increase in rate and amplitude. Swallowing movements and stertor occur at times and, although apparently unconscious, the patient may recall things spoken. Rough movements may greatly increase the patient's excitement, and the operation should not be attempted during this stage.

The *third stage*, that of *surgical anesthesia*, is reached after about three minutes, and is indicated by one or more stertorous respirations; automatic regular

breathing, loss of reflexes; full, rather rapid, regular pulse; dilated or contracted pupils and partial muscular relaxation. If too much nitrous oxid is given, the patient quickly becomes asphyxiated, rigid, or convulsed; if too much oxygen, he quickly returns to the second stage. Great skill, constant attention, a reliable apparatus, and air-tight face-piece are necessary to maintain an even stage of surgical anesthesia for prolonged operations. Anoxemia and hyperoxemia are almost invariable. Preliminary narcotism by morphin and hyoscin aids and, for relaxation, the addition of a small percentage of ether vapor is often desirable.

The *fourth stage*, that of *asphyxia*, is to be avoided. Premonitory signs are *hyperpnea* (excessive breathing) followed by dyspnea with cyanosis, convulsive expiratory movements, muscular spasms, feeble sighing respirations which gradually cease, followed by weak, then imperceptible, pulse, and death.

Fig. 385.—Nasal inhaler for the administration of nitrous oxid-oxygen or ethylene oxygen for operations within the mouth. Consists of a moldable or plastic rubber hood with a valve-like flap inside to accommodate an unusual shape of nose. The tubes emerge from either side and connect to the breathing tube. An exhaling valve similar to the face inhaler is provided, and an elastic harness about the head holds the inhaler in place.

Dangers.—Prolonged anesthesia, if irregular and especially if with a slight or deep cyanosis, may be followed by acidosis and evidence of parenchymatous damage, such as nausea, vomiting, headache, and depression that may last several days. If the skull is opened under gas-oxygen, the swollen brain may be damaged by protrusion through the opening, with resulting palsy. Temporary mental derangement, weakness of heart action, syncope, and functional nervous symptoms occasionally occur after the anesthesia.

Properly given for moderately prolonged operations, there is no irritation of the mucosa of the respiratory tract and little damage to normal kidneys, liver, or other parenchymatous organs. The services of a skilled anesthetist are essential. A transient two- or three-minute nitrous-oxid anesthesia is the safest general anesthetic. Prolonged gas-oxygen anesthesia, particularly in unskilled hands, is as dangerous as chloroform.

Contraindications.—1. A *feeble, obstructed*, or *crippled respiratory mechanism.* The gas apparatus imposes undue strain upon children under four.

2. Conditions in which vascular hypertension is dangerous, as *aneurysm, arteriosclerosis, hemiplegia, senility, operations on the brain.*

3. *Degenerative disease of parenchymatous organs* seriously exacerbated by anoxemia, hypercapnia, and acidosis, as chronic degenerative disease of liver or kidneys, diabetes, alcoholism, polysarcia, chronic alcoholism.

4. *Pulmonary disease*—pulmonary tuberculosis, pneumonia, and other acute or chronic diseases of the lungs—may be exacerbated by the stimulated, straining, irregular respirations. In pulmonary disease, however, nitrous oxid is preferable to ether, but not to ethylene.

Administration.—For continued anesthesia 14 to 22 per cent. of air or 10 to 20 per cent. of oxygen are required. Women and children require more

air than men. Continued anesthesia may be produced by: (1) *Pure nitrous oxid*, the mask being raised and the patient given a breath of air every three to ten respirations. (2) *Gas-oxygen apparatus* arranged for mixture of definite percentages of nitrous oxid, gas, and oxygen. This is to be preferred for gas-oxygen administration.

After the patient becomes accustomed to breathing through the mask, 95 per cent. of nitrous oxid with 5 per cent. oxygen is given until the second stage is reached, when oxygen is gradually added until the proper percentage for the patient is determined. The anesthesia is then continued under this percentage,

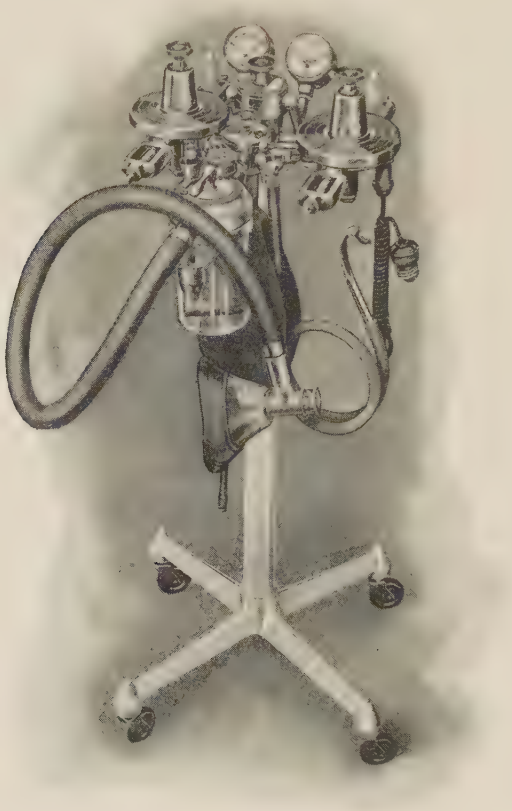


Fig. 386.—The Heidbrink anesthesia machine for use with nitrous oxid, ethylene, oxygen, carbon dioxid, and ether.

with such modification as exigencies may indicate. The zone of anesthesia is narrow and difficult to maintain. Excess of nitrous oxid is indicated by loss of pink color, by pallor or cyanosis, stertorous respirations, rigidity, convulsive movements, or fall in blood-pressure, with little increase in pulse rate. A pink color should be maintained throughout the anesthesia. Relaxation should be obtained by small and, if possible, transient additions of ether vapor and more oxygen, not by increasing the asphyxiation with nitrous oxid. Stimulation of respiration to ventilate the lungs or increase the intake of nitrous oxid may be produced by the limited use of rebreathing or the addition of 5 or 10 per cent.

of carbon dioxid. Excessive rebreathing may cause nausea, vomiting, post-anesthetic headache, and serious acidosis. Gas-oxygen also may be given by the *Meltzer-Auer method* of intratracheal insufflation.

ETHYLENE

Ethylene (olefiant gas, C_2H_4) is a colorless gas with a peculiar phosphorus-like odor, produced by the dehydration of ethyl alcohol. In 1829 Thomas Nunnely, a surgeon of Leeds, produced anesthesia by a combination of ethylene and chlorin, but was not satisfied with the results obtained. In 1918 Arno B. Luckhardt began to experiment with ethylene, and in 1923 introduced it as an anesthetic in human practice. For anesthetic purposes ethylene is used in combination with oxygen, and in its action and administration resembles nitrous oxid-oxygen, except that it is more powerful, has a wide anesthetic zone, is more easily managed, causes less cyanosis, and produces somewhat greater relaxation of the voluntary muscles.

Physiologic Action.—The respirations under ethylene anesthesia are slightly depressed, being slow, regular, and somewhat shallow, as in normal sleep. An overdose may cause death from respiratory failure. The pulse may be slightly slowed and the blood-pressure show a reduction of 10 to 15 mm. of mercury. The skin is dry, pink, and warm. The mucous membranes are not irritated, and the secretion of mucus or saliva is not increased. The blood is bright red, there being probably a combination between the ethylene and the hemoglobin. The gas is rapidly eliminated, chiefly through the lungs. No evidence of injury to the kidneys has been noticed after the anesthesia.

Administration.—The cone is held slightly above the face, and a mixture of 95 per cent. of ethylene and 5 per cent. of oxygen used. In ten seconds the cone is tightly applied to the face and the oxygen increased to 10 or 15 per cent. After inhaling the gas for ten seconds the peculiar phosphorus-like odor is no longer perceptible to the patient. In thirty seconds or a little longer analgesia appears, followed by more or less relaxation of the voluntary and involuntary muscles. In narcotized patients the respiratory depression may delay the induction of anesthesia unless carbon dioxid is added. For abdominal operations the relaxation may be insufficient, necessitating the addition of ether or of local anesthesia. In any case it is dangerous to attempt to obtain complete muscular relaxation by saturating the patient with the gas. After removing the mask consciousness returns in two to four minutes, and the patient vomits in about 30 per cent. of cases. In ten to fifteen minutes the patient is usually able to get up and walk about. Properly given, ethylene is as safe or safer than nitrous oxid-oxygen and, having a wider zone of anesthesia, requires much less skill for its successful administration.

Objections.—The chief objection to ethylene is its highly explosive quality. It may be ignited by a cautery, open flame, sparking commutator on an electric fan or other motor, or the static spark. To avoid the latter, the anesthetist, patient, operating table, mask, rebreathing bag, and apparatus used should be grounded. Ethylene is not inflammable or explosive if less than 5 per cent. is mixed with air. Five to 10 per cent. mixtures are explosive, higher percentages are inflammable, but not explosive. With oxygen, ethylene is violently explosive

at 25 per cent., and ignites, but does not explode in percentages above 60. Ethylene, having about the specific gravity of air, may drift a considerable distance. Mixtures of ethylene and oxygen subjected to high pressure may explode spontaneously. Contaminations of the gas by carbon monoxid has caused serious poisoning.

Ethylene Versus Nitrous Oxid.—Ethylene, apart from its odor and explosive qualities, is preferable to nitrous oxid in nearly every field. The margin of anesthesia and safety is wider, the even administration therefore easier, the anoxemia less, the respirations quieter, and bleeding from wounds less than with nitrous oxid. Ethylene is especially useful in operations on the thyroid and in patients with diabetes, nephritis, and other conditions in which cyanosis and acidosis are to be feared.

The preliminary use of morphin with atropin or hyoscin usually is desirable, and frequently, to obtain sufficient relaxation, ether must be added to the gas mixture. For safety the largest amount of oxygen compatible with anesthesia should be used throughout the administration.

Acetylene apparently is inferior to ethylene as an anesthetic, and with *amylene*, *carbon tetrachlorid*, *ethylbromid*, and *methylene bichlorid* may be ignored by the surgeon.

Ethyl chlorid is a very volatile liquid, having a sweetish ethereal odor. It boils at $12\frac{1}{2}^{\circ}$ C., and must be kept in sealed or specially closed glass or metal receptacles. On reaching the external air it boils, rapidly evaporates and freezes, with the production of a snow-like deposit. It is a very powerful and dangerous anesthetic, producing anesthesia within one minute.

Administration.—Ethyl chlorid is administered upon single layers of gauze or stockinette, upon which it is sprayed in the open method, as in the use of the Ware inhaler. In the closed method the ethyl chlorid ampul is broken in a suitable apparatus, the gas collected in a rubber bag, which is used for breathing and rebreathing. After three or four deep breaths of the gas an analgesia appears, which may deepen after removal of the mask and continue for thirty seconds, permitting short operations. If the inhalation continues the patient rapidly passes into the second, third, and fourth stages of anesthesia. Cessation of respiration, followed by stoppage of the heart, may occur with great suddenness. Signs of an overdose are widely dilated, fixed pupils, great pallor, and gasping or intermittent respirations. The anesthetic is more dangerous than chloroform and has been used for very short operations, such as the extraction of teeth, the opening of abscesses, or as preliminary to the use of ether.

The *dose for surgical analgesia* of an adult is 5 c.c. It is a very strong respiratory depressant, and should not be combined with chloroform anesthesia. Ethyl chlorid is one of the active agents of *somnoform*, which has largely been used by dentists, and consists of 5 parts of ethyl bromid, 35 parts of methyl chlorid, and 60 parts of ethyl chlorid. *Anesthol* is a mixture of 17 per cent. of ethyl chlorid, 36 per cent. of chloroform, and 47 per cent. of ether. The use of these dangerous anesthetics can rarely be justified.

Carbon Dioxid.—As emphasized by Henderson, carbon dioxid, properly used, is a valuable stimulant to the respiration and circulation during anesthesia. The gas, compressed in a steel tank with 90 or 95 per cent. of oxygen, is carried

to the face-piece with or without admixture with the anesthetic vapor. It is used: 1. **To increase the absorption of an anesthetic:** With slowed and shallow respirations, as occur in the narcotized patient, the saturation of the blood by ethylene, nitrous oxid, and other anesthetic may be unduly delayed or prevented. The addition of 3 to 5 per cent. of carbon dioxid to the anesthetic vapor, by increasing the frequency and depth of respirations, shortens the induction period, increases the depth of the anesthesia, and makes the vapor effective. The carbon dioxid is discontinued as soon as surgical anesthesia is obtained.

2. **To eliminate the anesthetic:** By discontinuing the anesthetic vapor, and giving 3 to 5 per cent. of nitrous oxid with oxygen or air, the respirations are stimulated, the circulation increased, the ventilation of the lungs improved, and the elimination of the anesthetic speeded. Carbon dioxid, therefore, is indicated in depression from overdose from the anesthetic, and to hasten recovery at the termination of the anesthetic.

3. **To increase the blood-pressure and to stimulate respiration and circulation:** In collapse or depression during spinal and other forms of anesthesia the inhalation of 5 per cent. of carbon dioxid with oxygen is useful.

INTRAVENOUS ANESTHESIA

Oré of Bordeaux introduced intravenous anesthesia in 1872, using a solution of *chloral hydrate* in water. Serious complications followed, and the method was abandoned. Burkhardt revived the method in 1909, using a 5 per cent. solution of *ether* in warm physiologic saline or in Ringer's solution. Later the addition of 5 per cent. of paraldehyd was found to give a more intense and even anesthesia.

Isopral (in 1½ per cent. solution) and *hedonal* (in 0.75 per cent. solution) are also effective.

Technic.—The needle is inserted in a vein of the arm or leg, and the limb fixed on a suitable splint. By means of a rubber tube and buret the anesthetic solution is allowed to flow into the vein by gravity until anesthesia is produced. The patient passes through the usual stages of anesthesia. The stage of excitement is shortened, and the surgical stage is reached in about five minutes. The patient's tongue should be held forward, and the reflexes watched as carefully as during inhalation anesthesia. From 50 to 100 c.c. of solution should enter the vein each minute. As soon as anesthesia is obtained, the flow is regulated and reduced, if possible, to 30 to 60 drops per minute. As the reflexes return, the flow is increased. About 1000 c.c. of solution is required for each hour of anesthesia. Not more than 250 c.c. of the solution of isopral should be used and, after this amount has been given, the anesthesia should be continued under ether. A preliminary narcotism is desirable. If the flow is interrupted, the patient may quickly come out of the anesthesia, or the needle become occluded by clots unless a slight flow of saline solution is continually used. Secondary edema of the lungs may follow the introduction of large quantities of fluid, and secondary effusions in serous cavities, thrombosis of the veins, and secondary pulmonary embolism occur. The method is more dangerous than inhalation anesthesia, and should have a very restricted use.

CHAPTER XXVII

REGIONAL ANESTHESIA

Methods.—*Regional anesthesia* is produced by the use of local anesthetics, applied or injected, and includes the following methods:

A. **Block or conduction anesthesia** acts upon nerve-roots or trunks proximal to the field of operation.

1. *Spinal-cord block* is not feasible.

2. *Spinal nerve-root block:* Intradural anesthesia, spinal anesthesia, lumbar anesthesia, rachianesthesia.

3. *Extradural intraspinal block:* Sacral anesthesia, caudal anesthesia.

4. *Paravertebral block:* (a) *Paracervical block.* (b) *Parathoracic block.* (c) *Paralumbar block.* (d) *Parasacral block, presacral block, postsacral* or *transacral block.*

5. *Ganglion block*—ganglion anesthesia.

6. *Splanchnic block*—splanchnic anesthesia.

7. *Plexus block* (plexus anesthesia): (a) Cervical. (b) Brachial (Crile, Kulenkampff, Hirschel). (c) Lumbar. (d) Sciatic.

8. *Neural block:* Peripheral or cranial nerve block, as trigeminal, ulnar, median, sciatic, etc.

9. *Field-block*, by a wall of anesthesia built about the area of operation.

B. **Regional vascular anesthesia** affects nerve-trunks and nerve-endings: (1) *Venous anesthesia.* (2) *Arterial anesthesia.*

C. **Peripheral anesthesia** is purely local, and is produced in the field of operation. It chiefly affects nerve-endings in the area of operation. (1) *Infiltration anesthesia* is induced by injecting the skin, mucosa, or subcutaneous, submucous, or other tissues. (2) *Instillation anesthesia* is used for the conjunctiva, urethra, bladder, etc. (3) *Surface anesthesia*—produced by applicator, swab, or powder—is practically useful only on mucous, serous, or denuded surfaces.

LOCAL ANESTHESIA

Local anesthetics produce anesthesia by: (1) The abstraction of heat. (2) Chemically interrupting conduction in sensory nerves or nerve-endings, as with cocain, butyn, and stovain; or (3) by protoplasmic poisoning, as with quinin.

Local Anesthesia by Cold (Arnott's Anesthesia).—Paré noted the reduction in pain while operating upon a soldier when the temperature was 14° F. below zero. Cold arrests conduction in sensory and motor nerves.

Refrigeration is produced: (1) By the *application* to the skin *of ice and salt*, which may be wrapped in gauze; (2) by a *spray of ethyl chlorid* or methyl chlorid, ether, or rhigolene. The skin and subcutaneous tissues being frozen, minor operations of short duration (such as the opening of superficial abscesses) are painless. With ethyl chlorid the spray is directed from a distance about the part. Evaporation and freezing are aided by blowing upon the part. Consolidation

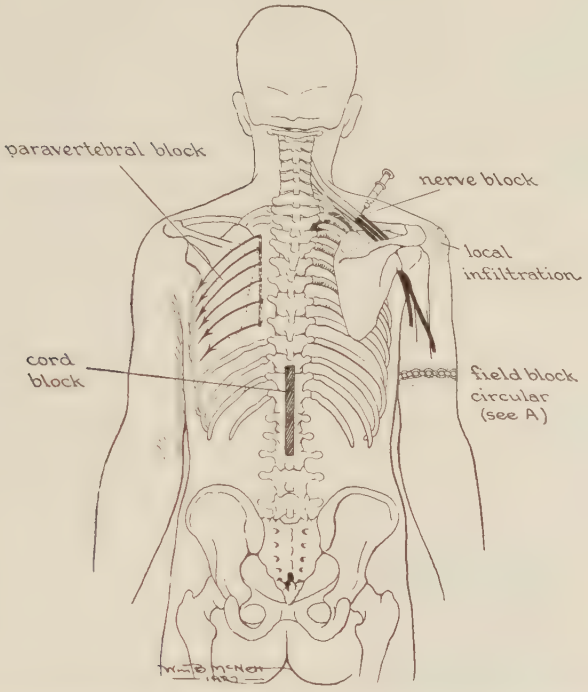


Fig. 387.—Methods of local anesthesia by root or cord block (spinal anesthesia), paravertebral block, nerve block (brachial anesthesia), circular field block, and local infiltration.

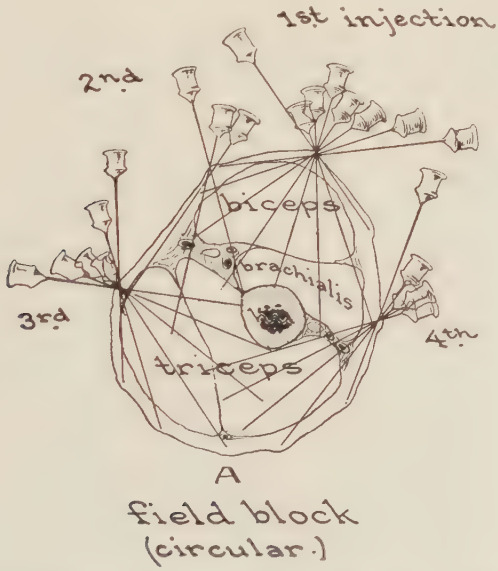


Fig. 388.—Local anesthesia, circular field block, illustrating the manner in which the needle is introduced for the production of a glove anesthesia of the arm and hand below the anesthetic diaphragm.

and freezing suddenly occur, when the incision is promptly made within the frozen area. The freezing and thawing of the tissues, however, is painful.

Chemical local anesthetics include *certain vegetable alkaloids*, as cocain, tropacocain, quinin and urea, and the *coal-tar derivatives*, procain, alypin, apothesine, stovain, butyn, tutocain, eucain, eucain lactate, phenacain, orthoform, and phenol. These drugs arrest conduction when applied to sensory and motor nerves. With the exception of quinin and urea, they produce a transient anesthesia, lasting from a few minutes to three or four hours, depending on the activity and dose of the drug and the vascularity of the area treated. By adding adrenalin a local ischemia is produced, and the anesthetic action is prolonged and intensified.

Skin: None of the chemical local anesthetics are efficient through the unbroken skin.

Mucous Membranes: The anesthetic is used in solution, paste, or powder, and applied by dropper or cotton swabs. The preferred drugs are: *Butyn*, 2 per cent. solution; *cocain*, 4 to 10 per cent. solution; *phenacain (holocain hydrochlorid)*, 1 per cent. solution, for the conjunctiva; and alypin, 4 per cent. solution, for the urethra.

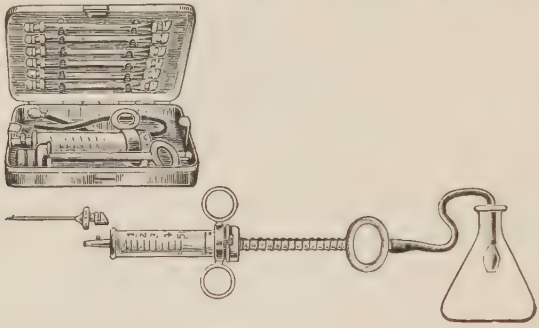


Fig. 389.—Babcock's self-filling syringe for local anesthesia.

Subcutaneous Injection: *Procain (novocain)* is used in $\frac{1}{4}$ to 2 per cent. solution, and is the least toxic and preferred anesthetic for subcutaneous injection.

Spinal Anesthesia: Stovain, procain, and apothesin are preferred.

Local anesthetics that do not cause vasoconstriction (such as procain) are rendered more effective by the addition of epinephrin.

Cocain is the alkaloid of *Erythroxylon coca*. It is a powerful local anesthetic and a dangerous, habit-forming drug. It causes intense local vasoconstriction with shrinkage and pallor of vascular tissues, followed by secondary engorgement, vasoparesis, and tendency to hemorrhage. When absorbed, it produces stimulation of ideas, phantasies, pallor, headache, vomiting, and depression of circulation and respiration. Death has occurred from the absorption of 0.03 gm. ($\frac{1}{2}$ gr.) or more. If injected into the blood-stream, it may cause instant arrest of respiration and circulation. Absorption from a surface, especially the urethra, has repeatedly caused death. Locally, cocain is a mild protoplasmic poison. In the conjunctival sac, it produces superficial exfoliation of the cornea; and in wounds and tissues aching pain, as the analgesia wears off, and slightly

retarded healing. The crystals are usually free from pathogenic bacteria, but solutions rapidly develop bacterial growth unless rendered antiseptic by the addition of chlorbutanol, phenol, or alcohol. Cocain is decomposed by alkalies and, gradually, by boiling. Solutions are prepared by dissolving the crystals or tablets in sterile cooled water, or saline or Ringer's solution just before use. Infection rarely follows the use of such solutions, as it does from solutions which have stood for hours or days.

Application.—The solution is usually applied by a dropper, or upon cotton pledgets.

Eye: For the eye, 2 to 4 drops of a 2 to 4 per cent. solution in physiologic saline is instilled every three minutes for fifteen minutes, if cataract extraction or iridectomy is to be done. In the removal of foreign bodies from the cornea or conjunctiva, 2 drops of a 2 per cent. solution gives sufficient anesthesia in from three to five minutes, and the pupil is dilated for one-half to one hour, facilitating ophthalmoscopic examination. Patients find the mydriasis and loss of accommodation objectionable.

Nose: For the nose and pharynx, a 4 to 10 per cent. solution is carefully applied by cotton swabs. It shrinks and anesthetizes the mucous membrane and submucous layers. In certain extensive resections of bone or cartilage, or enucleation of tonsils, the deep injection of a 1 per cent. procain-epinephrin solution should be added. For rapid intense local action, an application made of a paste of powdered cocain and epinephrin is useful. Ten minutes after the mucosa of the nose is painted with a saturated or a 35 per cent. solution of cocain in 1 : 1000 epinephrin solution, the accessory sinuses may be opened and drained without pain. While the intense local vasoconstriction limits the absorption of the drug, reducing the danger of poisoning, the paste or strong solution should be used with great care.

Larynx and Trachea: The drug, in 2 to 4 per cent. solution, is applied by a spray or cotton swab to reduce the local reflex and spasm, obtund sensation, and to shrink the tissues.

Urethra: Not more than 1 dram (4 c.c.) of a 4 per cent. solution should be introduced. This should be removed by irrigation of the urethra and bladder with a boric acid solution six minutes after application, to prevent absorption. Neglect of this rule has been followed by a number of deaths.

Anus and Rectum: A 4 per cent. solution may be applied by a swab, or a limited quantity of the paste or concentrated solution in adrenalin to fissures or other very sensitive areas.

Infiltration Anesthesia.—Cocain is efficient in $\frac{1}{4}$ to $\frac{1}{2}$ per cent. solution, but, on account of its toxicity, it should never be used when procain is available. *Schleich's solutions* are unphysiologic mixtures of cocain and morphin formerly used for local anesthesia.

Butyn (Para-amino-benzoyl-gamma-dinormal-butyl-amino-propanol Sulphate).—This is a powerful synthetic local anesthetic, not producing dryness of the tissues, ischemia, mydriasis, or local irritation as does cocain. In toxicity (in cats) it is about equal to cocain. It may be sterilized by boiling. Its action is more powerful and rapid than cocain, and it is less dangerous, as a smaller amount is required. For the normal eye a 0.5 per cent. solution of butyn

is more efficient than a 1 per cent. solution of cocain or eucain, but is less efficient than 1 per cent. solution of phenacain (holocain hydrochlorid).

Eye: Two or three drops of a 2 per cent. solution gives superficial anesthesia in one minute, sufficient for the removal of foreign bodies from the cornea. Four instillations three minutes apart give an anesthesia, five minutes after the last application, adequate for all the common operations on the eye.

For surface anesthesia of mucous membranes butyn is preferable to cocain. Like cocain, it is not advised for infiltration or spinal anesthesia.

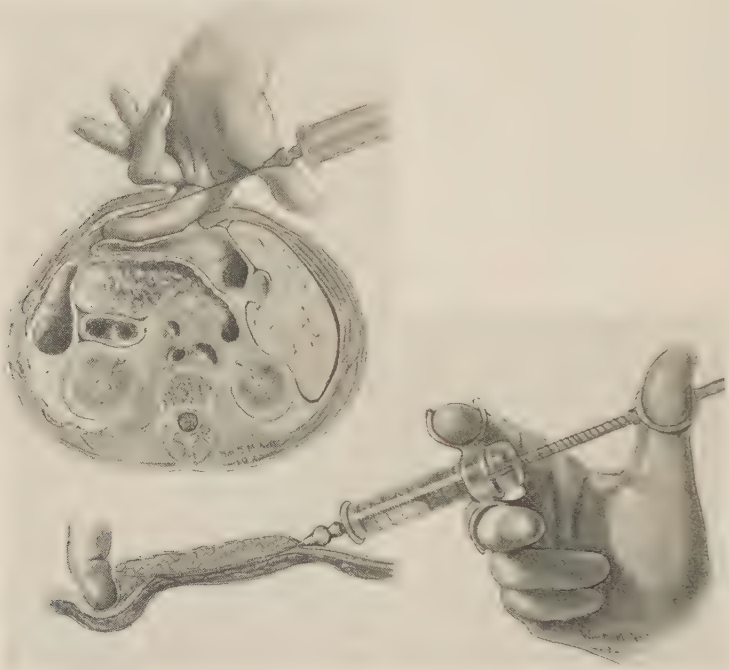


Fig. 390.—Induction of local anesthesia by pump syringe. The needle is fixed by a bayonet catch so that it will not become detached, and the piston contains a valve so that the syringe automatically refills when the piston is withdrawn. A rubber supply tube connects with the hollow thumb-piece. With this 5-c.c. syringe a solution of a local anesthetic can be very rapidly and accurately injected with little fatigue. The lower figure shows the infiltration of the skin. The upper figure shows the method of producing anesthesia of the peritoneum around the wound. A small incision is made through the peritoneum; then, guided by the finger introduced into the peritoneal cavity, the needle is introduced into the preperitoneal space, which is widely and freely infiltrated with from 50 to 200 c.c. of a 1 or ½ per cent. solution of procain. This deep infiltration is very valuable in producing relaxation of the abdominal wall adjacent to the wound.

Procain (**novocain**) was discovered by Braun in 1905, and is one-third as effective and seven to ten times less toxic than cocain. Watery solutions up to 10 per cent. have little local irritating or toxic action on the tissues. It may be sterilized and resterilized by boiling, without marked effect upon its anesthetic properties. The solution finally becomes yellow when decomposed. It is the safest and best anesthetic for local infiltration. In an adult over 500 c.c. of a 1 per cent. solution may be injected subcutaneously without evident toxic ef-

fect. Intravenous injections cause pallor, collapse, serious depression of respiration and circulation, and even death; should be treated by lowering the upper part of the body, the inhalation of ether, artificial respiration and, if necessary, by cardiac massage and intravascular injection of epinephrin (see Resuscitation, page 500). It can be applied pure to the cornea and to freshly denuded surfaces, without causing pain or subsequent edema. For infiltration anesthesia, $\frac{1}{2}$, 1, or 2 per cent. isotonic solutions in saline or Ringer's solution are used. Greater concentrations are unnecessary and should not be used, even though they are only feebly toxic. The addition of epinephrin in the strength of 1:60,000 to 1:100,000 (or 3 to 5 minims to each 30 c.c.) doubles the intensity and quadruples the duration of the anesthesia. Procain is used on denuded (burns) or serous surfaces, but not upon mucous surfaces, as it is a feeble and ineffective surface anesthetic as compared to cocain or butyn.

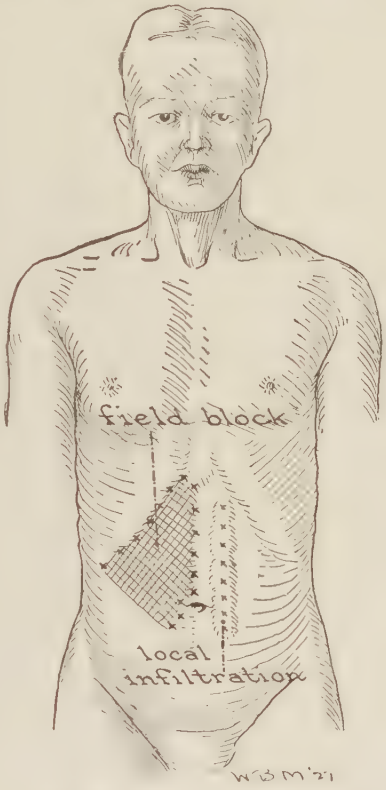


Fig. 391.—Illustrating local infiltration of the skin upon the left side and a field block of the lower intercostal nerves for an abdominal operation upon the right side. Crosses mark points for the introduction of the needle. By using a long needle fewer points for introduction are required.

Stovain (**benzoyl = dimethylamino = methylpropanol hydrochlorid**) occurs in very soluble, small, colorless, brilliant crystals. It withstands boiling at 115° C. It is nearly as powerful and only one-half as toxic as cocain, dilating instead of contracting the blood-vessels. It hemolyses red cells, and irritates and, in stronger solutions, kills tissue cells. Necrosis or local gangrene follows the free injection of solutions stronger than 2 per cent. in the less vascular tissues. It is active on mucous surfaces in 4 to 10 per cent. solutions, but causes greater cellular damage than butyn. For deep anesthesia it is injected in $\frac{1}{2}$ to 1 per cent. solution. Its use is largely restricted to spinal anesthesia.

Alypin (**benzoyl = dimethylamino = methyl=dimethylaminobutane hydrochlorid**) is readily soluble in watery solutions, and is less active, slightly less toxic, and more irritating than cocain when used subcutaneously. It is not a mydriatic or a vasoconstrictor. It is active on mucous surfaces, and has chiefly been employed to anesthetize the urethra and bladder in 1 to 4 per cent. solutions. Not over 5 c.c. of a 4 per cent. solution should be used. Death has followed the injection of larger amounts into the urethra and bladder. *Butyn* is preferable in the eye and nose, *stovain* in the dura, and *procain* for infiltration anesthesia.

Apothesine (**gamma=diethylamino=propyl=cinnamate hydrochlorid**)

occurs as nearly odorless, faintly bitter, neutral, soluble crystals. Aqueous solutions are stable and withstand boiling, but are precipitated by alkalies. It resembles procain, but is less active and twice as toxic. It is relatively inefficient when applied to mucous membranes. It has been used with epinephrin in 0.5 to 2 per cent. solution for infiltration anesthesia, and in doses up to 2 c.c. of a 4 per cent. solution for spinal anesthesia.

Hydrochlorid of quinin and urea, in watery solutions of from 0.25 to 1 per cent., when injected into the skin, causes necrosis; in tissues, the formation of fibrinous exudate, which delays the healing of wounds. Its anesthetic effect lasts for days, so it may be used to inhibit the sense of pain in intense and persistent neuritis, and itching in circumscribed chronic eczema.

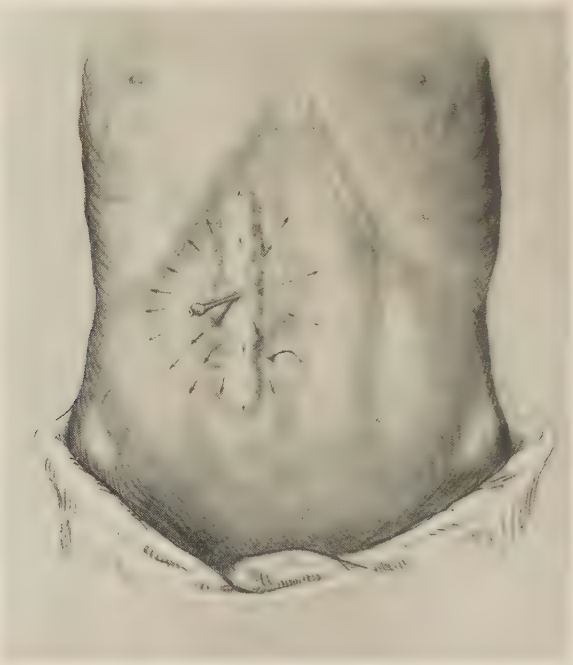


Fig. 392.—Field block with single point of injection. The line of incision is first infiltrated by the long needle and peripheral infiltration obtained by carrying the needle along lines radiating from the center.

Phenacain (Holocain Hydrochlorid, Ethenyl=paradiethoxy=diphenyl=amidin Hydrochlorid).—Five minims of a 1 per cent. solution dropped in the eye produce smarting, followed in five minutes by anesthesia of the cornea and conjunctiva, without mydriasis or loss of accommodation. For this reason it is largely used in ophthalmology. The solutions are permanent and withstand boiling, but are decomposed by alkalies, including the alkali in glass.

Slightly soluble local anesthetics are used in dusting-powders, troches, ointments, and suppositories. They are nearly free from toxic or irritant action, but may delay wound healing. *Ethyl aminobenzoate* (*benzocain* and *anesthesin*) may be used in from 5 to 20 per cent. strength in boric acid, or mixed with sugar of milk, talcum, or zinc stearate.

Butesin picrate, a yellow, amorphous, odorless, slightly bitter powder, combines the anesthetic action of butesin with the antiseptic properties of picric acid. It is used to relieve the pain of burns, ulcers, or abrasions in a 1 per cent. ointment, a 5 per cent. dusting powder, or in standard watery solution (1 : 1400). It is soluble up to 1 per cent. in cotton-seed oil.

Orthoform is a fine, white, neutral, odorless, tasteless, crystalline powder, almost insoluble in water. It is used in emulsion, tablet, troche, powder, or ointment form. The dose for internal use is 0.5 to 1.13 gm.

Chlorbutanol (*chloretone, trichlor-tertiary-butyl-alcohol*) is a white, crystalline, volatile substance with a camphoraceous odor and taste. It is slightly soluble in water (8 in 1000). It is hypnotic, antiseptic, and locally anesthetic. Powdered and dusted upon burns or wounds, it causes local stinging followed by local anesthesia. Absorption from the local area may lead to drowsiness and even deep coma.

SPINAL ANESTHESIA

Spinal anesthesia, lumbar anesthesia, medullary anesthesia, intradural anesthesia, rachianesthesia or, more accurately, *rhizanesthesia, radicular anesthesia,* is a nerve-root anesthesia produced by the injection of a local anesthetic into the cavity of the spinal arachnoid. In no other way can so extensive an analgesia be produced with as small a dose of a drug. Consequently, of all anesthetics it produces the least general protoplasmic disturbance or toxemia.

Physiology.—An interruption of conduction in the spinal nerve-roots is produced by introducing a local anesthetic within the spinal arachnoid, with inconspicuous toxic effect upon liver, lungs, kidneys, and other parenchymatous organs, or upon general metabolism. The drug is not injected into the cord or nerve-roots, but into the free cerebrospinal fluid. All of the nerve-roots reached by a sufficiently active solution of the local anesthetic are temporarily blocked, with the following effects:

I. **Posterior Roots:** Loss of pain, tactile, temperature, and muscle sense in the involved segments. The widest and most intense effect is upon the pain or protopathic sense.

II. **Anterior Roots:** Loss of voluntary movement, paralysis, muscular relaxation, absence of superficial and deep reflexes.

III. **Sympathetic Fibers (White Rami Communicantes running in the Anterior Roots):** A. *Vasomotor palsy,* varying with number of rami affected. When all white rami from the second dorsal to the second lumbar are blocked, there is complete vasomotor relaxation of the entire body and, if the head and shoulders are raised, the patient becomes pulseless and, from cerebral anemia, unconscious.

B. *Fall of Blood-pressure:* In high abdominal anesthesia the fall in systolic pressure is 30 to 70 mg. of Hg, in midabdominal anesthesia it is 20 to 40 mg., and in lumbar anesthesia 0 to 20 mg. Hemorrhage from a wound is in proportion to the fall in pressure.

C. *Local Effects:*

1. *Heart.*—The contractions of the heart become slower and weaker from: (a) Interruption of cardio-augmentor nerves, (b) diminished *vis à tergo,* and (c) unopposed action of the inhibiting vagus.

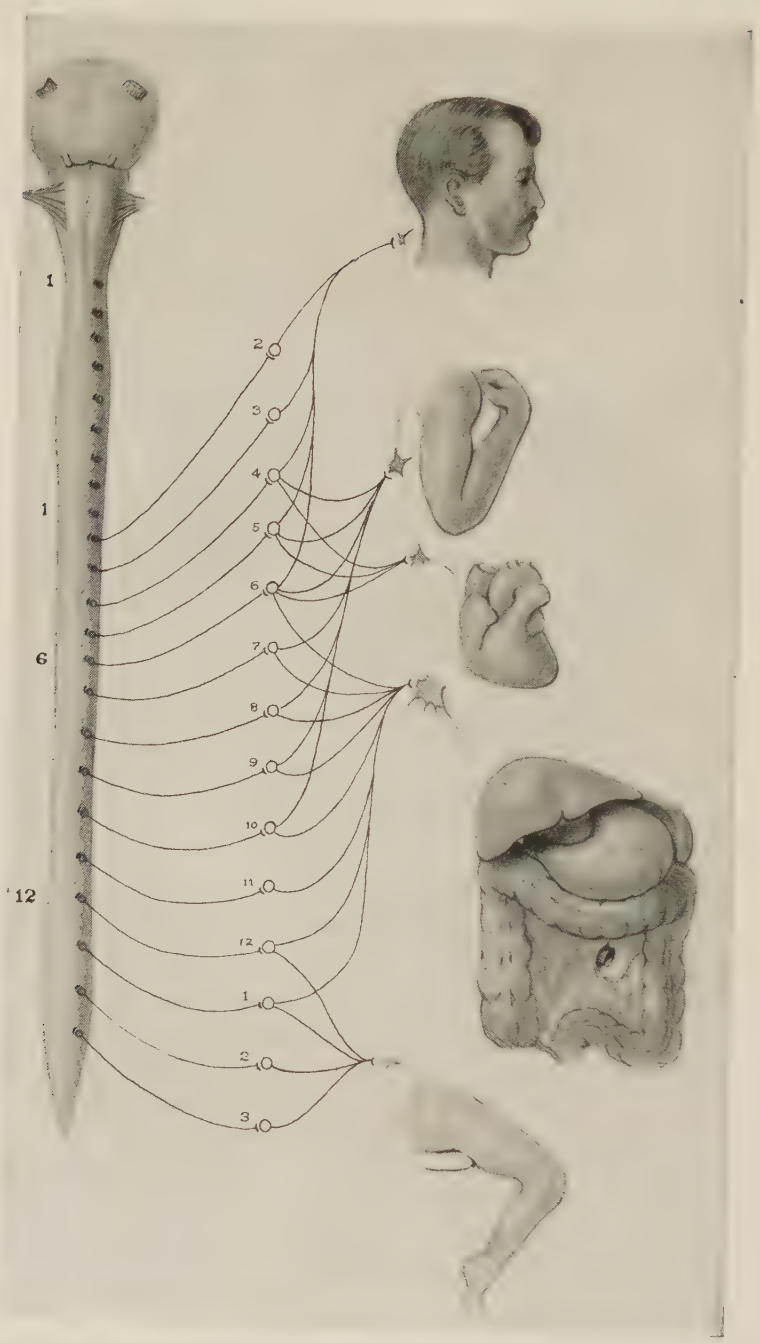


Fig. 393.—The physiology of the fall of blood-pressure under spinal anesthesia. From the second thoracic to the third lumbar the anterior nerve roots carry white rami which supply through the intervening ganglia the blood-vessel walls of the entire body. The fall in blood-pressure during spinal anesthesia depends on the number and position of the anterior nerve roots blocked by the drug. When all the nerve roots carrying white rami are interrupted there is vasoparesis of the entire body.

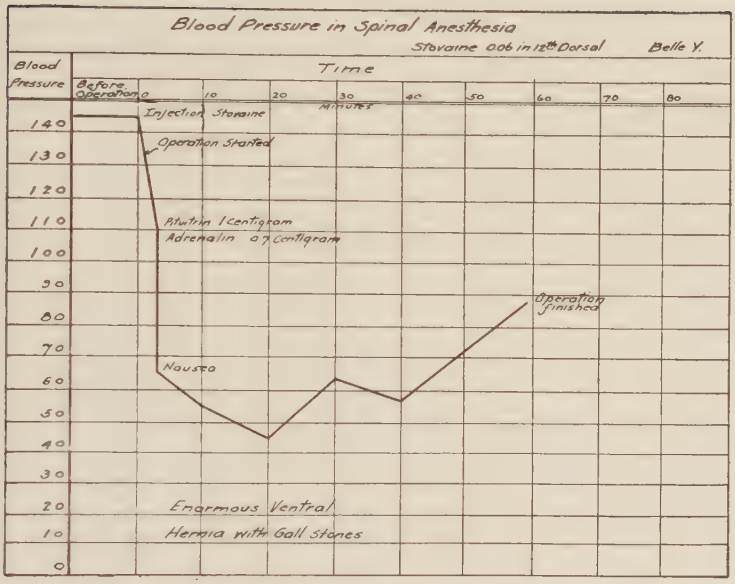


Fig. 394.—Diagram showing the effect of spinal anesthesia upon the blood-pressure. If only the lower spinal segments are involved there is but little fall in blood-pressure. If the thoracic segments are involved there is a rapid and very marked fall in blood-pressure. The effect produced is, of course, modified by the concentration and activity of the anesthetic employed.

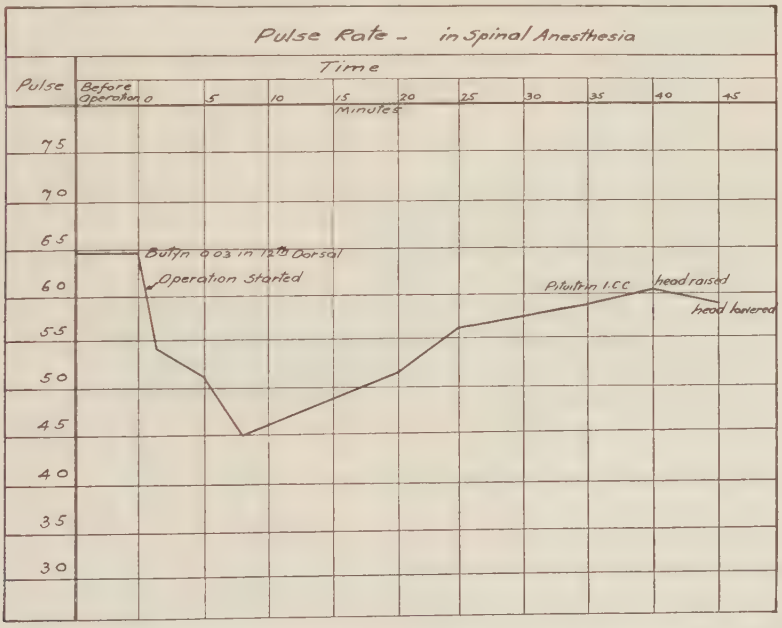


Fig. 395.—Bradycardia of spinal anesthesia not influenced by intravenous injection of pituitrin.

2. *Respiration.*—This is quiet, slow, of small amplitude, and largely diaphragmatic from paralysis of the abdominal and thoracic muscles of respiration. If the anesthetic blocks the third, fourth, and fifth anterior cervical roots, phrenic

paralysis occurs with apnea and death, unless artificial respiration is used and continued until conduction in the affected roots returns. During the analgesia there is reduction in the mucous secretion of the respiratory tract from the fall in blood-pressure.

3. *Gastro-intestinal.*—An increase in peristalsis, strong gastric and intestinal contractions occur, with relaxation and incontinence of the anal sphincters. Inhibition through the vasomotor fibers is blocked, while peristaltic stimulation through the vagi and by the intrinsic ganglia of Auerbach and Meissner continues unopposed. A free involuntary evacuation, therefore, often follows the release of constricted intestine. Transient nausea and slight vomiting are frequent with the higher forms of spinal anesthesia occurring, five to fifteen minutes after the injection, with the maximum fall in blood-pressure. Post-anesthetic nausea and vomiting are not produced by rachianesthesia.

4. *Kidneys.*—Urinary elimination is temporarily reduced from the fall in blood-pressure, but without evidence of local irritation. Ureteral peristalsis is active.

5. *Skin.*—The skin is dry, warm and, when there is a marked fall in blood-pressure, pallid. Ashy gray pallor or cyanosis is always ominous.

6. *Uterus.*—Active forcible contractions of the uterus in labor continue, but are without the aid of the voluntary abdominal muscles. Hemorrhage during labor and abortion is reduced.

7. *Consciousness* is not affected, except indirectly by apnea or cerebral anemia.

Clinical Symptoms.—The injection of an active drug is instantly followed, in the distribution of the roots blocked, by sense of slight warmth and tingling; immediately succeeded by loss of pain sense, tactile sense, temperature sense, muscle sense, and by motor paralysis. From loss of sense of position the patient cannot tell whether the leg is raised or lowered. Vomiting, unless aided by gravity through lowering of the head, is ineffective from paralysis of the muscles of the abdominal wall. As might be expected by the root location of the block, the area of protopathic loss (loss of sensation to pain) is larger than the area of epicritic loss (loss of sensation to touch). Therefore, near the margins of the analgesic zone, the patient may feel the cut of the knife, although it gives no pain. In from ten minutes to several hours, depending upon the dose and the activity of the drug used, the effects wear off without unpleasant sensation and, in reversed order, with return of muscle sense and motion, epicritic and, finally, protopathic sensation.

Procain (novocain) is the weakest drug, and may fail to give complete muscular relaxation and loss of tactile and pressure sense.

Butyn is dangerous because of a powerful and prolonged effect upon the white rami, with great vasomotor depression.

Cocain is difficult to sterilize without deterioration. It is very powerful, and has largely been abandoned from disagreeable and dangerous effects produced.

The maximum adult dose is about $1\frac{1}{2}$ c.c. of the percentage solution indicated in the following table. The dose should vary with the capacity of the spinal canal, not the weight of the patient. Young robust patients withstand large doses better than the obese, aged, or debilitated.

DOSE AND CONCENTRATION OF SPINAL ANESTHETICS

Drug.	Concentration necessary for effective anesthesia.	Dose in centigrams.					
		1 year.	2 years.	6 years.	12 years.	15 years.	Adult.
Procain	8 per cent.	3	4	5	8	10	12
Stovain	4 "	1½	2	3	4	5	6
Apothesine	4 "	2	2½	3	4	4	8
Tropocain	5 "	2	2½	3	4	5	7
Tutocain	4 "	1½	2	2½	3	3½	6
Butyn	2 "	1	1½	2	2½	3	3
Cocain	2 "	1	1½	2	2½	3	3

Solution.—The solution is extemporized at the time of injection by dissolving the sterile anesthetic powder or tablet in withdrawn cerebrospinal fluid or other liquid, or previously prepared and sterilized solutions sealed in ampuls of insoluble glass may be used. By using prepared solutions the technic

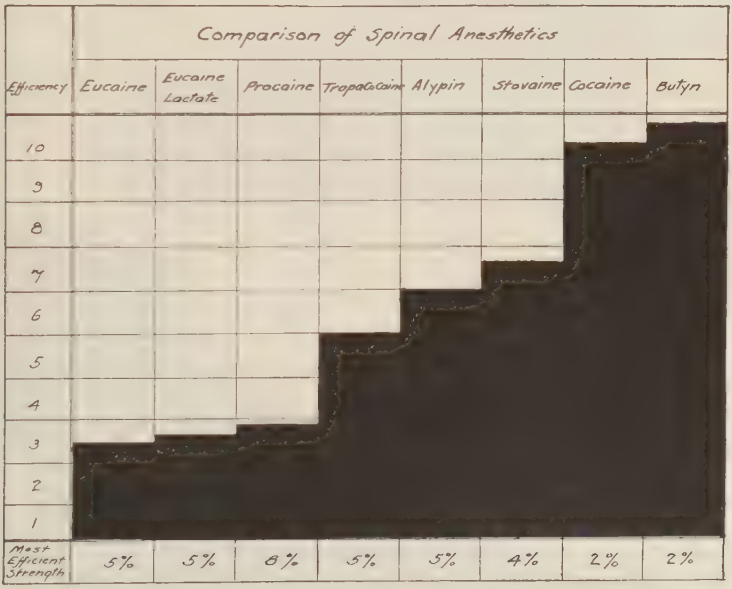


Fig. 396.—A clinical comparison of spinal anesthetics. Different local anesthetics used in spinal anesthesia vary in efficient percentage strength and in activity. The efficiency is arbitrarily expressed in decimals. It will be noted that stovain, cocain, and butyn are the most powerful of the drugs given.

of injection is simplified, time is saved, and it is easier to control the specific gravity of the solution injected.

The directions here given refer to the following light solution, which enables the Trendelenburg position to be used:

Babcock's Light Solution: Stovain, 0.08 gm.; lactic acid, 0.02 c.c.; alcohol,

absolute, 0.2 c.c.; distilled sterile water to make 2 c.c. This is sealed in a sterile ampul of alkali-free glass, and sterilized at 65° C. for twenty minutes on three successive days. Before use the ampuls are submerged in flavine or eosin alcohol to detect cracks in the glass. The dose for adults is 1.1 to 1.5 c.c.

Duration of Anesthesia.—The intensity and duration of the analgesia varies directly with the dose and concentration, as shown in the following table:

Dose of stovain.	*Duration of anesthesia.*
3 centigrams	12 to 18 minutes
4 "	30 to 50 "
5 "	40 to 60 "
6 "	60 to 90 "

Localization and Diffusion of Drug.—The nerve-roots first reached by a concentrated solution of a local anesthetic are affected most intensely, and for the longest period of time. Therefore, the point of injection should be opposite the nerve-roots supplying the operative field.

The height of analgesia is raised by: (1) *High point of injection.* (2) *Forcible injection.* (3) *Specific gravity of solution* in relation to position of patient. (4) *Degree of cerebrospinal decompression:* Diffusion is better when decompression by withdrawal of spinal fluid is used before injecting the anesthetic. (5) *Bulk of fluid* injected.

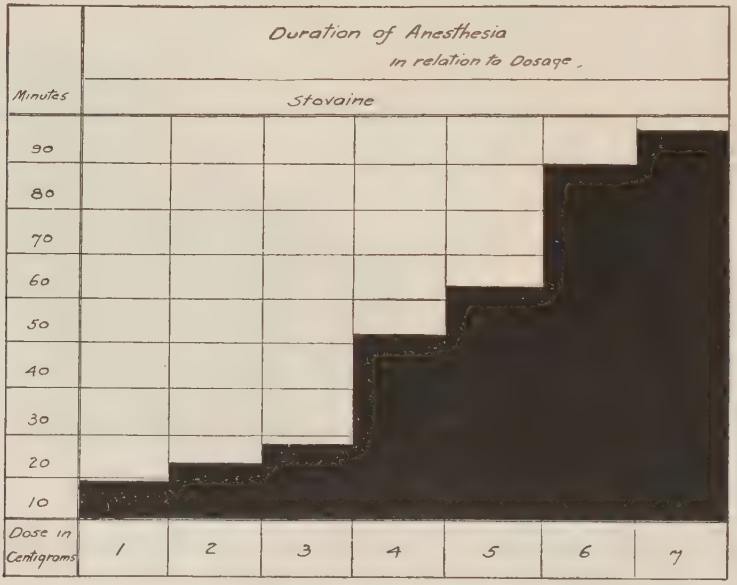


Fig. 397.—The duration of the spinal anesthesia is inversely as the square of the dosage. Thus 1 cgm. of stovain gives anesthesia for about eight minutes; 3 cgm., for about eighteen minutes, and 6 cgm., for about ninety minutes.

Gravity Localization.—A. Babcock's Method.—The specific gravity of the anesthetic solution is reduced below that of cerebrospinal fluid by the addition of 10 per cent. of ethyl alcohol, and the patient's body instantly inclined after

the injection, so that the shoulders are at least 3 inches below the level of the hips. This is most efficient when used with varying points of injection, as follows:

1. *High injection* through the eleventh or twelfth dorsal interspace, for operations on the upper abdomen, stomach, liver, or gall-bladder.

2. *Midinjection* through the first lumbar interspace, for operations on the midabdomen, intestine, appendix, or kidney.

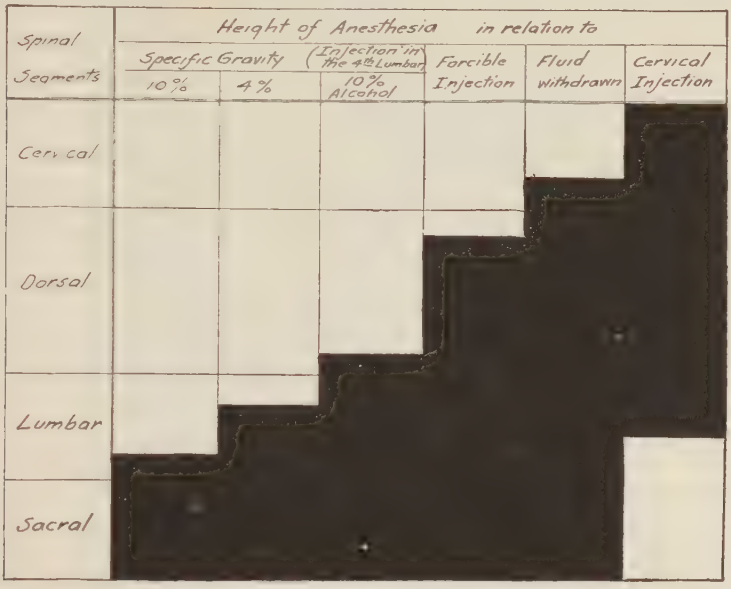


Fig. 398.—Height of anesthesia. The height of anesthesia from a given dose of a local anesthetic injected through a definite interspace will vary according to the specific gravity of the solution used, the force of the injection, the amount of fluid withdrawn, and the decompression of the dura. A heavy 10 per cent. solution of stovain injected through the fourth lumbar interspace rarely induces anesthesia above the lumbar segments. By dilution, so that a 4 per cent. solution is injected, the midlumbar region is reached. By decreasing the specific gravity below that of the cerebrospinal fluid, as when 10 per cent. alcohol is added, the area of anesthesia is higher and the lower dorsal segments are affected. Forcible injection, the bulk of injection, and the amount of fluid previously withdrawn greatly influence the height of anesthesia. If the injection is made through a higher interspace, as in the cervical region, analgesia of all of the upper nerve roots may be produced, but as impulses continue to travel through the spinal cord the lower lumbar and sacral segments carry sensation and motion.

3. *Low abdominal injection* through the second lumbar interspace, for operations upon the lower abdomen and legs.

4. *Sacral anesthesia* through the third or fourth lumbar interspace, for operations upon the anus, perineum, sacrum, or coccyx.

Unless an excessive dose has been used, the drug becomes fixed, preventing further diffusion in the first ten minutes after the injection.

B. **Barker's Method.**—A solution made heavy by the addition of glucose or other medium is used, and retained in the desired part of the spinal canal by sufficient elevation of the hips and shoulders of the patient, during and after the injection.

Technic.—Apparatus consists of an accurately calibrated, all-glass Luer syringe of 2 c.c. capacity, and a 20 or 21 gage rustless steel or nickeloid needle,

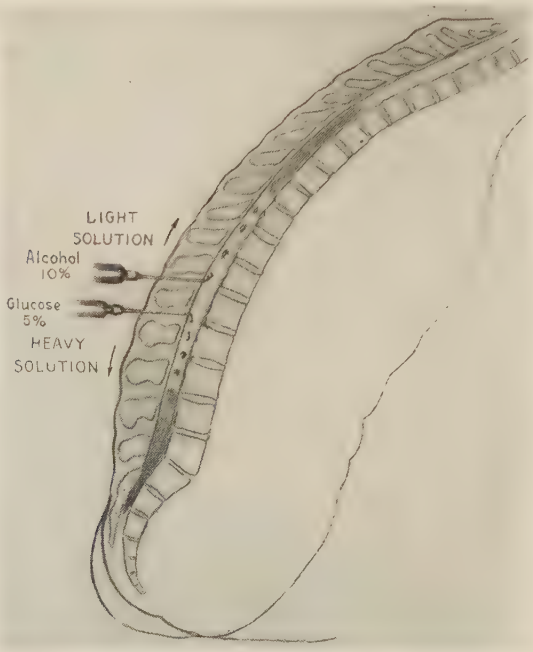


Fig. 399.—Influence of gravity in spinal anesthesia. If a heavy solution is employed it falls in the spinal canal, while a solution made light by the addition of alcohol rises.

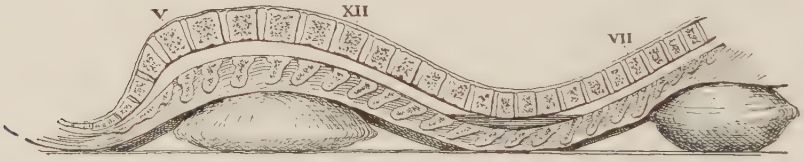


Fig. 400.—Barker's method: An anesthetic solution, made much heavier than cerebrospinal fluid, is held to the desired part of the cord by suitable pads placed under the patient.

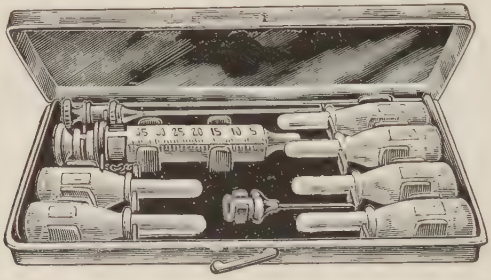


Fig. 401.—Equipment for spinal anesthesia.

9 cm. long, with a sharp but obtuse concave point and a well-fitting stylet. Immediately before using, the syringe and needle are boiled for ten minutes

in distilled water without contact with alkali or with other instruments. They are brought directly to the operator while boiling hot, who permits no one else to touch them. The hot syringe raises the temperature of the solution to about that of the patient's body.

Position.—The patient sits on the side of the operating table, well back from the edge, his legs dependent. An assistant, standing on a stool facing the patient, properly arches the exposed and carefully sterilized back by carrying his left arm back of the patient's neck to the front of the abdomen, where he

Fig. 402.—Method of holding patient for intradural injection. The assistant stands on a stool above the level of the patient, with the patient's neck under his left axilla. With his hands he grasps the patient's wrists and by bearing downward and backward upon the patient's neck, the back is properly arched. The back should be arched rather than inclined forward.

grasps the crossed wrists of the patient. As he pushes backward on the abdomen, his left axilla presses the patient's neck downward and backward, arching but not inclining the back.

Localization of Spinal Interspace.—The seventh cervical spine is the most prominent, the first dorsal is slightly less so. A line connecting the spines of the scapulæ crosses the third dorsal spine; one connecting the angles of the scapulæ, the seventh cervical spine. The twelfth dorsal interspace lies between the two most prominent spines of the midback. The lowermost rib border, at its junction with the erector spinæ muscle, is opposite the first lumbar spine.

A line connecting the crests of the iliac bones crosses the fourth lumbar spine or interspace. After localizing a spine, the operator counts up or down to the desired interspace.

Injection.—The center of the selected interspace is marked by the nail of the gloved thumb, as the ball of the thumb presses against the lower edge of the spine above. The needle is entered in the midline, at right angles to the skin, until the resistance of the interspinous ligament is felt, when the stylet is

Fig. 403.—Spinal anesthesia: Localization of the spinous interspaces. The first thoracic spine, the vertebra prominens, is easily located. The third thoracic interspace is opposite the spines of the scapula, the seventh opposite the lower angle of the scapula. The twelfth thoracic interspace shows the greatest depression in this portion of the back. The fourth lumbar interspace is on a level with the iliac crests. By determining any one of these spines any desired interspace may be located by counting up or down.

withdrawn. The needle is then carried cautiously forward, a few millimeters at a time, until the slight resistance and snap as the dura is punctured is noted, when resistance to the needle suddenly stops and cerebrospinal fluid escapes. The needle is now slightly rotated, to make sure that all of the beveled point is through the dura. To avoid the lamina, the needle should not be inclined up or down. To avoid the nerve-roots, the needle should not deviate laterally. The injection should not be given until cerebrospinal fluid is running freely

from the needle, and is made rather slowly, with uniform pressure. It is preceded and interrupted by several withdrawals of the piston to obtain thorough diffusion. The needle is then quickly withdrawn and the patient's shoulders instantly lowered. The injection requires about ten seconds. For the minute puncture with a sharp needle no anesthetic or dressing is required. With feeble patients, and for Barker's method, the injection is made in the lateral position.

Anesthesia, proved by the relaxation of the abdominal muscles and by pinching the skin, should immediately follow in 98 per cent. of the injections; the operation, unless a brief one, should be started without delay, so that it may be completed before sensation returns. If there is no anesthesia after waiting ten minutes, the injection should be repeated without reduction in dose, preferably using the next higher or lower interspace. With a high injection

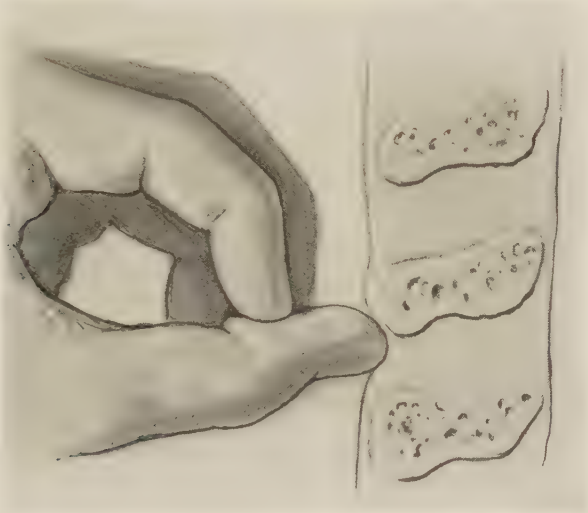


Fig. 404.—Marking the point for the introduction of the needle. With the end of the gloved thumb pressed against the lower edge of the spinous process the finger-nail is caused to make a line upon the skin, through which the needle is entered.

sensation may be retained in the distribution of the sacral plexus. In certain cases it is desirable to reinforce or prolong the analgesia by local anesthesia, narcotic anesthesia, or the inhalation of nitrous oxid, ethylene, or ether, carried only to the stage of light analgesia. Chloroform or ethyl chlorid by inhalation should never be used with spinal anesthesia, and the second or third stage of any general anesthetic is dangerous while the patient is in the hypotension of spinal anesthesia. If returning sensation and a rise of blood-pressure to the preoperative level show that the patient is out of the spinal anesthesia before the operation has been completed, then local anesthesia or general anesthesia, with ether or other desirable anesthetic, may be induced.

Unconsciousness during spinal anesthesia may be obtained at a somewhat increased risk by: (1) Light narcotic anesthesia, or (2) by ethylene or nitrous-oxid-oxygen analgesia.

Fall in blood-pressure, if alarming, is antidoted by: (1) *Conjoint use of procain-adrenalin* as a local anesthetic. From 100 to 300 c.c. of $\frac{1}{4}$ per cent. solution of procain containing 1 : 60,000 epinephrin are injected about the wound. This is very valuable for a prolonged operation on a debilitated or obese patient. (2) *Intramuscular injection* of 0.7 c.c of a 1 : 1000 solution of *epinephrin.* (3) *Intravenous injection of saline,* Ringer's, or Locke's solution containing adrenalin (see page 502). This is the most powerful method of raising blood-pressure. (4) *Lowering head of patient* to prevent cerebral anemia. (5) *Subcutaneous injection of* 0.04 gm. *ephedrin.* (6) *Inhalation* of 5 to 10 per cent. *carbon dioxid* in oxygen.

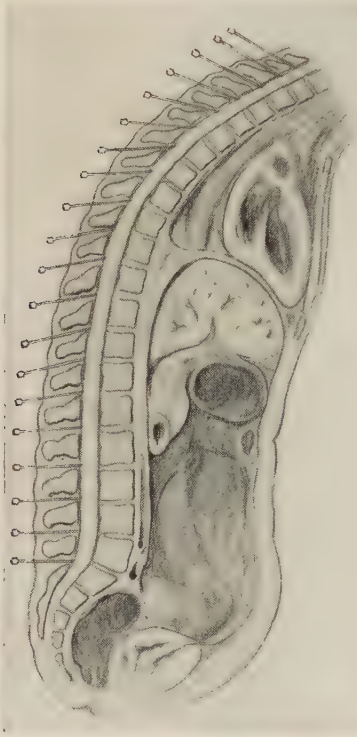


Fig. 405.—Showing the proper direction for introducing the needle for spinal anesthesia. In the lumbar region the needle should enter about the middle of the interspace, at right angles to the skin. In the middle and upper thoracic regions the needle is inclined progressively cephalad.

Contraindications to Spinal Anesthesia.—A. **Hypotension,** especially when facilities for immediate resuscitation are not available, from: (1) Extreme shock; (2) hemorrhage with exsanguination; (3) obesity; (4) myocardial degeneration; (5) aortitis and obstructive cor-

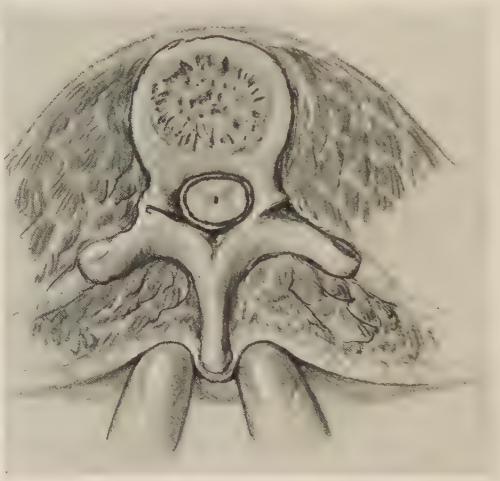


Fig. 406.—Orienting the point of the needle. The location and direction of the spinous process is determined by the two index-fingers pressing on either side of the process.

onary disease; (6) asthenia, starvation, exhaustion, advanced senility, extreme cachexia, advanced sepsis with cyanosis, or a moribund state.

B. **A systolic pressure under 100.**

C. Associated **high diastolic** and **low pulse pressure.**

D. **Lack of trained assistants** to constantly watch the patient, to take five-minute blood-pressure readings, and to be prepared for instant resuscitative measures.

E. **Critical** or **unfavorable community** or a neurotic psychotic patient, who

may attribute to the unconventional anesthetic any real or imagined symptom that later may develop.

F. **Tabetics** or those with other forms of spinal disease, unless the patient clearly understands that the anesthetic will not stay the progress of his disease.

Advantages.—(1) Minimal general toxemia; (2) absence of respiratory, hepatic, or renal irritation or stimulation; (3) complete muscular relaxation, facilitating reduction of dislocations and fractures, abdominal operations, and reducing intra-abdominal trauma; (4) peristaltic contraction and stimulation, especially valuable in ileus; (5) relaxation of sphincters, desirable in rectal operations; (6) fall in blood-pressure, reducing hemorrhage and protective in arteriosclerosis, aneurysm, and certain other cardiovascular diseases; (7) lipoids not dissolved, desirable in presence of auricular clot, as in mitral stenosis;

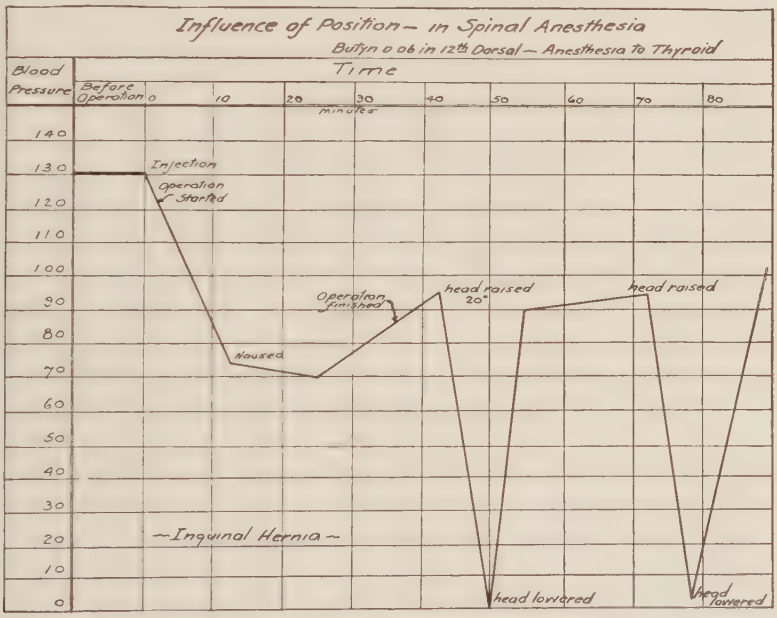


Fig. 407.—Temporary vasoparesis observed in high spinal anesthesia causing the patient to become pulseless as soon as the head was raised to the level of the rest of the body. An excessive dose of the powerful anesthetic, butyn, was used.

(8) no pre- or post-operative excitement or delirium; (9) progressive shock of operation antidoted by rise in blood-pressure as the anesthesia passes off; (10) absence of secondary delirium, nausea, and vomiting.

Morbidity.—1. **Headache** after spinal anesthesia should have about the same incidence as after simple lumbar punctures. It is due to: (a) Use of large needle, with secondary dural leak; the diameter of the needle should not exceed 20 gage; (b) irritating solutions, and (c) infection. The pain is chiefly occipital, is increased by raising the head, and is associated with stiffness and rigidity of the back of the neck. It is to be treated by rest in bed, with the head and shoulders on or below the level of the hips, by an ice-cap to the head, and the use of caffein and acetphenetidin.

2. **Abducens Palsy:** The internal squint is due to an infection probably involving the center in the medulla. It has an incubation period of seven days, involves one or both nerves, and lasts from a few days to several weeks. With the better solutions now used it is rare, and has not occurred in over 15,000 consecutive injections of alcoholized stovain solution.

Treatment.—Repeated spinal punctures if there is excessive pressure. Methenamin, 4 gm. daily, well diluted.

3. **Incontinence or spasm of vesical or urinary sphincters** occurs as after the use of ether, but is not due to the spinal anesthesia alone.

4. **Secondary palsy** in man does not result from the anesthetic drug, but occurs from: (a) *Injury* or *injection* of a *spinal root* by the needle, in which case the patient has violent root-pain on the introduction of the needle or fluid; (b) *Cerebrospinal disease*, or tabes, transverse myelitis, or carcinoma of the vertebræ. (c) *Hysteria* or *neurosis.*

Definite palsy from puncture of the cord by a fine needle is unlikely unless the cord is disrupted by an injection within its substance.

Mortality is 1 : 10,000 when carefully used and supervised, and 1 : 200 when carelessly used upon patients who are poor operative risks.

Necessary Precautions.—An assistant should constantly *watch the color*, *pulse*, and *respiration*, and should record the *blood-pressure* every five minutes. Constriction or pressure upon the chest or abdomen should be avoided. Shallow and infrequent respirations are treated by occasional admonitions to the patient to take deep breaths, by the inhalation of aromatic spirit of ammonia, a very little ether, or, better, 5 per cent. carbon dioxid in 95 per cent. oxygen. The vascular hypotension is especially dangerous in very obese, asthenic, starved, shocked, anemic, or toxic patients, or those with myocardial degeneration. If there is marked hypotension, 10 minims of epinephrin or 0.04 gm. of ephedrin is given intramuscularly. Centrally acting drugs, as strychnin and atropin, are valueless. If the systolic pressure falls to 30 mm. of Hg., an intravenous injection of warm physiologic saline or Ringer's solution should immediately be started and, if the pressure continues to fall, sufficient epinephrin is added to the solution to raise the systolic pressure above 40. The dose, which will depend upon the patient and the effect produced, will range from $\frac{1}{4}$ minim to 100 minims of the 1 : 1000 solution. To avoid overstimulation, the injection is interrupted as soon as the systolic pressure begins to ascend, to be resumed intermittently later if this is found to be necessary. Injection of 5 minims of epinephrin in the left ventricle, cardiac massage preferably through the abdomen, and artificial respiration may also be required, if one fails to maintain the blood-pressure and the heart is arrested. Few patients require the intravenous injection. Mouth-to-mouth insufflation for artificial respiration should not be forgotten.

Associated Anesthesia.—An associated infiltration anesthesia with procain-epinephrin is valuable with spinal anesthesia, to raise the blood-pressure and to increase and prolong the analgesia. Ether, nitrous oxid, or ethylene, carried only to the stage of analgesia and not to full surgical relaxation, may be combined with spinal anesthesia. Deep general anesthesia or chloroform are dangerous, and should not be used while the patient is *under spinal anesthesia.*

CAUDAL, SACRAL, AND PARAVERTEBRAL ANESTHESIA

Epidural Anesthesia (Löwen, 1910).—*Sacral anesthesia*, or *Extradural anesthesia*, is produced by the application of local anesthetics to the sacral nerves in: (a) *Caudal* or *extradural block;* (b) *presacral block;* or (c) *transsacral block.*

Caudal or extradural block (Cathelin, 1903) is induced by the extradural injection of a solution of novocain or other anesthetic through the sacral hiatus. The sacral hiatus is bounded by the fourth sacral spine and the two cornu of the sacrum.

Technic.—The patient should be prone, without elevation of the body. The skin is asepticized, the sacral hiatus located, a fine trocar or needle entered at right angles to the skin, and passed through the dense membrane which covers the opening. The hub of the needle is then depressed so as to lie in the axis of the canal, when it is pushed upward for 3 or 4 cm. The piston of an affixed syringe is then withdrawn and, if no blood or spinal fluid escapes, from 40 to 60 c.c. of a 1 per cent. or 20 to 30 c.c. of a 2 per cent. procain solution is gradually injected, taking five minutes for each 30 c.c. introduced. If the needle is outside the canal a subcutaneous swelling appears. Anesthesia occurs in about ten minutes, is complete in twenty minutes, and may last for two hours. It involves the distribution of the sacral and coccygeal nerves. The foot or head of the table is elevated or depressed, according to the region to be anesthetized. Caudal anesthesia is used for operations about the perineum, anus and rectum, and also during labor.

Toxic manifestations (with weak pulse, pallor, dilated pupils, and fall in blood-pressure) are not infrequent, and should be treated by the inhalation of aromatic spirit of ammonia or a little ether. The solution may even gravitate to the cervical region. Death has followed the entrance of the solution into the cavity of the arachnoid or into a blood-vessel.

Sacral Anesthesia.—The nerves passing through the sacral foramina may be blocked anteriorly by a needle introduced on either side of the anus (*presacral* or *anterior sacral anesthesia*), or by a needle introduced posteriorly through the ten points overlying the ten sacral foramina (*postsacral* or *transsacral anesthesia*). The latter is easier, more direct, involves skin areas more readily sterilized, and is preferred. In either case 5 c.c. of a 1 per cent. procain solution with 0.01 per cent. of epinephrin are injected in each foramen, making a total of 50 c.c. of solution used.

Anterior Sacral (Presacral) Anesthesia.—The patient is placed in the lithotomy position, and an anesthetic wheal raised by a fine needle midway between the anus and the tip of the coccyx on either side. Through these anesthetized points, a needle, 9 cm. long, is introduced and contacted with the inferior lateral border of the sacrum, 2 cm. from the midline. The needle is carried along the bone about 1 cm. into the fifth sacral foramen, where 5 c.c. of solution are deposited, and is then continued along the anterior face of the sacrum about 2 cm. from the midline into the fourth, third, and second foramina, which are separated by vertical intervals of about $1\frac{1}{2}$ or 2 cm. At each of these foramina 5 c.c. of solution are injected. The needle is withdrawn, a needle, 12 cm. long, introduced at the same point and, guided by a finger in the rectum, carried about

$2\frac{1}{2}$ cm. from the midline to the upper sharply curved portion of the sacrum, where the first sacral foramen is entered, at a distance of 9 or 10 cm. from the skin. Five c.c. of solution are injected here, and the injections are repeated upon the opposite side.

Transsacral Anesthesia (Posterior Sacral Anesthesia, Parasacral Anesthesia).—The patient is placed in a prone position with a pad under the hips, and small anesthetic skin wheals raised by injecting the anesthetic solution through a fine needle over each of the sacral foramina. The first point over the first sacral foramen lies 3 cm. lateral to the first sacral spinous process, or at a point 1 or 2 cm. mesial and inferior to the posterior inferior spine of the ilium. The second wheal is raised over the fifth sacral foramen, $1\frac{1}{2}$ cm. from the midline, just lateral to the middle of the sacral hiatus. Along the line connecting these two first wheals three intermediate skin infiltrations are made. The upper three are about 25 mm. apart, the lower two being about 20 mm. apart. Through each of these five localizing wheals a needle, 9 cm. long, is introduced to the cor-

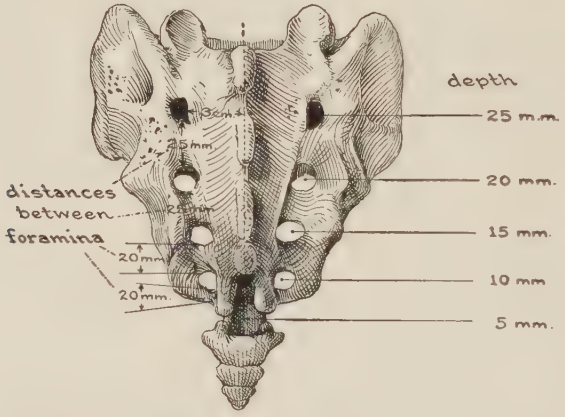


Fig. 408.—Sacral anesthesia. Posterior or transsacral anesthesia showing the distances between the foramina and the depths from the skin at which the injections are made.

responding foramen, 5 c.c. of the anesthetic solution being introduced at each point. Beginning above, the depths at which the needle should be introduced before making the injection are approximately 25, 20, 15, 10, and 5 mm. The injections are repeated upon the opposite side.

Sacral anesthesia develops after a delay of about fifteen minutes, and continues for one and one-half or two hours, giving an anesthesia of the external genitals, perineum, skin of the posterior surface of the thighs, anus, rectum, prostate, bladder, uterus, and urethra, but not the pelvic peritoneum. It is a valuable method of anesthesia for operations upon the perineum, rectum, bladder, and genital organs, not involving the peritoneum. The anesthesia may be extended and reinforced by the conjoint use of caudal anesthesia.

Objections to the method are: The multiple injections necessary, the time required for the establishment of anesthesia, and the percentage of insufficient anesthesias, varying from 10 to 40 per cent., dependent upon the skill of the anesthetist.

Brachial-plexus anesthesia, suggested by Crile, who exposed the plexus by incision, has been simplified by the methods of Kulenkampff and Hirschel. The former infiltrates the plexus just above the clavicle, close to the subclavian artery; and the latter, the branches of the brachial plexus through the axilla, on the medial and lateral side of the axillary artery. Ten to 15 c.c. of a 2 per cent. solution of procain is used. As a rule, fifteen minutes should elapse, to permit the diffusion of the drug into the adjacent nerve-trunks before the incision is made.

Brachial-plexus Anesthesia (Kulenkampff).—With the patient preferably in the sitting posture, the shoulder depressed, and the arm abducted to an angle of 45 degrees, a 6-cm. needle is introduced at the center of the upper border of the clavicle, in the direction of the third dorsal spine. The subclavian artery is localized and pressed medially by the index-finger, and contact made with the

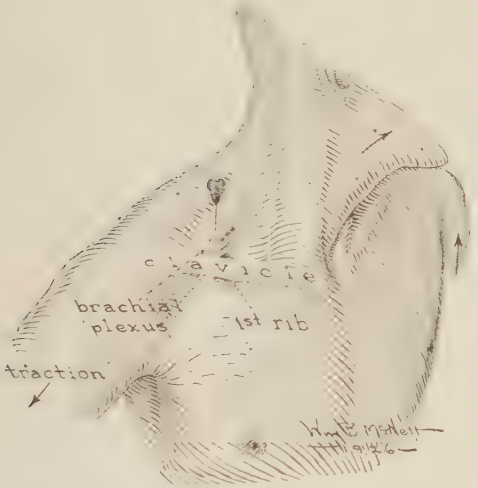


Fig. 409.—Brachial plexus anesthesia. The needle is introduced just above the center of the clavicle to the first rib and withdrawn slightly into the plexus, and the injection made, the arm and head being separated.

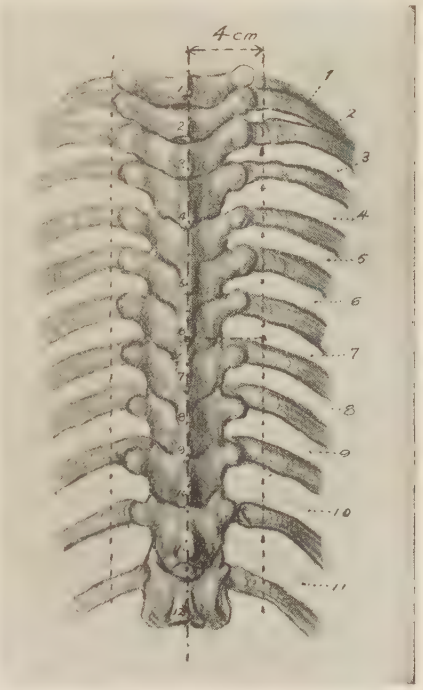


Fig. 410.—Paravertebral anesthesia. The needle is entered 4 cm. from the median line in the middle of the interspace.

first rib at a depth of about 3 cm. The needle is then withdrawn slightly into the plexus, aspirated to make sure it is not in a blood-vessel, and 10 c.c. of a 2 per cent. solution of procain-adrenalin injected. The proper position of the needle is shown by paresthesia in the fingers, from irritation of fibers in the median nerve. Unless this paresthesia is first produced by the needle, the injection will usually fail. If, after a delay of fifteen minutes, anesthesia and paralysis of the arm are not complete, the injection may be repeated. The duration of the anesthesia is from one to three hours.

Paravertebral Anesthesia (Sellheim, 1905).—The production of anesthesia of the thoracic wall by injecting a 1 per cent. solution of procain between the ribs close to the spine is of value. At this point the intercostal nerves lie

between the ribs, and have not entered the subcostal groove. The needle is entered 4 cm. from the midline, and is directed toward the body of the vertebra which it should strike just in front of the intervertebral foramen. It is then withdrawn slightly and 5 c.c. of the solution deposited.

Anterior Splanchnic Anesthesia (Braun).—The upper abdomen is opened under local anesthesia, the left lobe of the liver is retracted upward, the stomach drawn down, the index-finger is pressed against the gastrohepatic omentum above the arteria gastrica sinistra, to the twelfth dorsal or first lumbar vertebra, displacing the aorta and vena cava. The aorta being displaced to the left, the vena cava to the right. A fine needle 15 to 20 cm. long is passed over the index-finger to the bone, slightly withdrawn, aspirated to insure that it is not in a blood-vessel, and 50 to 70 c.c. of $\frac{1}{2}$ per cent. procain solution slowly injected in the retroperitoneal tissues, producing anesthesia in five to ten minutes which lasts from forty-five minutes to two hours. If splanchnic anesthesia is not feasible conduction anesthesia by injections into the omentum may be used. Twenty to thirty minutes after the splanchnic injection, nausea and vomiting followed by oppression, air-hunger, pallor, slow, weak pulse may occur.

In *posterior splanchnic anesthesia* (Kappis, 1913) a 12-cm. needle is introduced from the back, 7 cm. lateral to the twelfth thoracic spine, and is pushed forward at an angle of 30 degrees with the sagittal plane, contacting with the side of the vertebra. It is pushed forward about 1 cm. beyond the vertebra and 25 to 35 c.c. of a 1 per cent. solution injected. The injection is repeated from the opposite side and at times 20 c.c. is also injected opposite the first and second lumbar vertebræ.

Regional Venous Anesthesia (Bier, 1908).—Apparatus:

A. *Sterile:*

1. Buret graduated to 250 c.c., with 2 meters of rubber tubing and intravenous needle securely affixed.

2. Two hundred and fifty c.c. solution $\frac{1}{2}$ per cent. procain in warm normal saline.

3. Fifteen c.c. 1 per cent. procain, 5 c.c. Luer syringe, and fine needle.

4. Small scalpel, scissors, 3 mosquito hemostatic forceps, 15 inches 0 plain catgut, milliner's needle threaded with fine black silk.

B. *Not Sterile:*

1. Small flannel roller bandage.

2. Esmarch rubber roller bandage.

Seventy-five minutes and forty-five minutes before operation a hypodermic injection of morphin sulphate 0.011 gm. and hyoscin 0.0008 gm. is given.

Method.—1. The limb is emptied of blood by elevation, and an Esmarch bandage firmly applied from the phalanges to a point 5 cm. or more above the operative field.

2. Ten turns of a second Esmarch are smoothly and flatly applied as tourniquet over four turns of a flannel bandage. These must not be placed over joint, forearm or leg, and are placed just proximal to the first Esmarch bandage, which is now removed from the operative field, but left in place below this area.

3. The skin is sterilized by $3\frac{1}{2}$ per cent. tincture of iodin between the bandages.

4. By a needle introduced in a superficial vein under local anesthesia, from

30 to 50 c.c. of a $\frac{1}{2}$ per cent. solution of novocain in saline solution is introduced for the arm, and 60 to 100 c.c. for the leg. The anesthetic is prevented from escaping by clamping or ligating the vein. Complete anesthesia with muscular paralysis is noted within two minutes between the two bandages, and indirect anesthesia below the lower bandage soon follows; the anesthesia persisting as long as the proximal bandage is retained in place. Unfortunately, the patient soon begins to complain of pain from the proximal bandage, and insists that it be removed. This is the chief objection to the method. The anesthetic is promptly absorbed from the blood-vessels into the tissues, and so, after removal of all bandages, when the circulation is resumed there is no evidence of poisoning.

Arterial anesthesia (Toyanes, 1908; Ransohoff, 1900) is accomplished by the injection of the anesthetic into an artery instead of a vein. The vessels are isolated by a tourniquet as with intravenous anesthesia. It has no advantage over the former method.

CHAPTER XXVIII

THE OPERATION. PRE- AND POST-OPERATIVE TREATMENT

OPERATING-ROOM TECHNIC

The **operating-room staff,** including operators, assistants and nurses, should maintain the *highest possible personal hygiene,* with scrupulous care as to personal cleanliness. Daily baths, daily changes of underclothing, frequent shampoos, and constant care of the hands and nails are necessary. The teeth and gums should be maintained in the best hygienic condition. No acute or chronic infections of the respiratory passages or skin should be tolerated in the operating room. Occasional cultures from the hands and throats of members of the operating staff are desirable.

It is almost impossible to sterilize pustules, abrasions, or open wounds and, when upon the hands or arms, such lesions may cause infection despite the use of rubber gloves. Gloves are by no means constantly impermeable. The skin, particularly of the hands, should be kept smooth and free from chaps or roughness by the application of borated glycerol of rose water, lanolin, cold cream, or other unguent, after operations. The nails should be kept short, smooth, and polished.

Attention to personal hygiene, a smooth skin, and the use of mild non-irritating antiseptics will give greater freedom from wound contamination than will a rough irritated skin with frequent use of strong and irritating germicides. It is difficult to sterilize a rough or chapped skin, while many persons with a fine smooth skin can produce a practical sterility of the hands by a thorough washing with soap and hot sterile water. Rubber gloves are, of course, routinely worn for all operations and surgical dressings.

Talking should be reduced to a minimum in the operating room. Orders may be given largely by the use of signs made by the hands or arms. Coughing, sneezing, or other violent expiratory movements should be prevented, or conducted in such a way as to prevent contamination of objects that may have direct or indirect contact with the operative field. The experiments of Flugge and others have shown that, from the moist surface of the respiratory tract, liquid particles containing bacteria are ejected in coughing, sneezing, and loud speaking. These particles remain suspended in the air for a distance of about 7 meters, and then rapidly subside by gravitation. Greater numbers of watery particles are thrown off while speaking in guttural tones, coughing, or sneezing than in ordinary quiet respiration, when no bacteria leave the mucous surfaces.

Immediately before an operation the surgeon and assistants should substitute clean canvas or rubber shoes and a clean operating suit for the street clothing. The hair, being well brushed and free from dandruff, should be covered by a sterile cap. The face should be washed to remove dust and loose epithelial scales, and a sterile mask consisting of at least four layers of gauze applied over the nose and mouth.

Sterilization of the hands should consume fifteen minutes, the hands being *scrubbed* with an abundance of running hot water, and preferably a neutral potash (soft) soap. Sterile gauze pads or sterilized hand-brushes are used to aid the mechanical sterilization of the skin, and the removal of grease, dirt, and exfoliating epithelium. While pumice or cornmeal may be added to the soap to increase the mechanical effect, the use of abrasive substances, such as sand or harsh brushes which will lacerate the skin, should be avoided. A mixture of cornmeal, powdered castile soap, and mustard flour as a mechanical antiseptic soap-powder formerly had considerable vogue. The oil of mustard is antiseptic, the cornmeal a mechanical cleanser.

After scrubbing the hands for three minutes, the nails should be trimmed short so that there is no evident subungual space, and carefully smoothed. The

Fig. 411.—One-piece operating suit. Two buttons instead of tapes may be used.

scrubbing is then continued, paying particular attention to the crevices and folds about the nails, and noting that each hand and every side of each hand, finger, and arm to a point well above the elbows are given routine attention. *Sterilization is then completed* by applying: (1) *Seventy per cent. alcohol* well rubbed into all surfaces by gauze pads for two minutes, or (2) *Furbringer's method*—70 per cent. alcohol is applied for two minutes, followed by 1 : 1000 or 1 : 2000 bichlorid solution for at least one minute. To prevent irritation of the skin and blackening of the nails, the sublimate may be partially removed by rinsing in boric alcohol (saturated solution of boric acid, 30 parts; ethyl alcohol, 70 parts) or sterile water, or (most efficient) (3) a small handful of a powder consisting of 2 parts *chlorid of lime* and 1 part carbonate of soda is held in the palm of the hand, and mixed into a paste with a little sterile water. It is then carefully

rubbed into the skin of the hands and arms, with especial attention to the spaces about the finger-nails. The hands are then rinsed in sterile water, and boric alcohol applied to prevent irritation of the skin. Hexylresorcinol (1 : 1000) in 30 per cent. glycerin solution is not irritating, has a low surface tension favoring penetration, and is claimed to have about seventy times the antiseptic power of phenol.

A **sterile gown** handled only by the inner surface is then donned, taking care that the sleeves or other parts of the outer surface do not come in contact with any unsterile object. As the sleeve may come in contact with the wearer's face or neck, if he attempts to pull the gown about the shoulder or neck, this adjustment should be made by an unsterile assistant who grasps and fastens it from the back. The gown should not be used to grasp unsterile objects; nor should the hands or gloves be permitted to rest against it, as it may inadvertently have become contaminated by brushing against a bystander, table leg, stool, blanket, or other object during the course of the operation. The hands are dried with a sterile towel, thoroughly powdered with sterile talcum, and sterile rubber gloves with turned-down cuffs drawn on without contact between the outer surface of the glove and the hand. This may be accomplished by the aid of a nurse, who with sterile gloved hands supports the gloves from beneath the everted cuff; or by donning the first glove which is handled only by the inner side of the everted cuff, the second glove then pulled on by supporting it with the fingers of the previously gloved hand under the cuff of the glove. The cuffs are then turned up over the ends of the long-sleeved operating gown, without contact with their inner surface. If a glove is punctured or torn it is immediately replaced by another sterile one. Great care should be taken to prevent contamination of the glove or gown during the operation.

If **a number of operations are to be performed,** the cleaner or aseptic operations should be done first. Operations essentially septic—such as those upon the mouth, throat, nose, rectum, or for abscesses, ulcers, fistulæ, purulent accumulations, and the like—should be performed last to prevent the transference of infection. It is preferable that they be done in a separate and special operating room manned by a different personnel.

Between operations members of the operating staff should scrupulously avoid contact with infectious material by wearing gloves in digital examinations of the mouth, vagina, or rectum, and by using the *knife-and-fork* method in dressing infected wounds and in the handling of contaminated instruments, sponges, or other infectious material.

Personnel of the Operating Room.—For any serious operation four assistants are desirable besides the anesthetist: *Two trained assistants* to aid the operator during the operation; *one aseptic nurse* to look after instruments, ligatures, sutures, sponges, and pads; and *a second nurse* with unsterile hands, to bring supplies, arrange the patient on the operating table, open sterile packages, fasten gowns, and do whatever is necessary that those with sterile hands should not do.

The *anesthetist* should wear a sterile cap and gown, carefully cleanse his hands, and have fresh sterile appliances—mouth-gag, gauze, cone or face-piece, tongue forceps, and aspirator attachment—for each operation.

He should constantly watch the pulse, respiration, color, and mucous se-

cretions of the patient, and should, as far as possible, record the blood-pressure every five minutes of the anesthesia.

Resuscitation.—In every operating room appliances for immediate resuscitation should be kept close at hand, in condition for immediate use. For intravascular injections, a sterile funnel and a non-corrosive intravenous needle connected by 150 cm. of rubber tubing, a band for constricting the arm, a hemostatic forceps, a thumb forceps, a scalpel, a 1 : 1000 solution of epinephrin with a sterile dropper, and 1000 c.c. of warm sterile decinormal salt solution are needed. A 9- or 12-cm. 19 gage, hypodermic needle, with a Luer syringe of 2-c.c. capacity, should be at hand for the intracardiac injection of adrenalin. The personnel should be familiar with an approved technic for artificial respiration, intravenous and intracardiac injections, and cardiac massage.

The Operating Room.—The operating room should be kept at a temperature of between 75° and 85° F. and should be ventilated without draft, preferable with air screened from dust. It should be lined by tile, porcelain, glass, or other impermeable material and, to aid the operator's vision, the floor and side walls should have a dark neutral gray or green color to the height of 2 meters. The visibility of deep cavities is also aided, as suggested by Sherman, by surrounding the operative field with black, green or gray, instead of the usual glaring white fabrics. Illumination is more uniform if artificial light is employed instead of daylight. The light should come from one direction instead of from a number of cross lights or windows, and should be so arranged as to give diffusion and avoid shadows.

All unnecessary furnishings should be eliminated from the operating room, floor drains should be omitted, and dust should not be raised by sweeping or dusting. Tables and other furnishings should be wiped daily with 5 per cent. phenol or 2 per cent. liquor cresolis compound, and the floor and side walls wiped with a solution of chlorinated lime and carbonate of soda, or a 2 per cent. liquor cresolis compound solution. Septic wound secretions, sponges, and instruments should not be handled with ungloved hands, or scattered over the floor or other parts of the operating room, but should be received in appropriate receptacles, removed from the operating room, and promptly destroyed or disinfected.

Operations in Private Homes.—Emergency operations in homes should be performed without disturbing the furnishings or raising dust. To prevent staining, if the floor is carpeted, it should be covered by oil cloth, rubber sheeting, or several layers of newspapers, over which clean sheets are pinned. Couches, bureaus, and other furnishings should be covered by clean sheets, and the windows coated with soap or covered with thin white cloth for privacy. A kitchen or dining table will serve as an operating table, or a high narrow hospital cot may be used. The table may be tilted at one end by placing the legs upon a box. The top should be padded with blankets, and covered by oil cloth or rubber cloth and a sheet. Instrument and service tables are often improvised from a convenient covered bureau, table, ironing board, or chair. The instruments are safely sterilized by boiling in cooking pans or basins. Domestic basins, pitchers and sterile water should be prepared by boiling in a washboiler. A steam cooker forms an efficient sterilizer for gauze, towels, sheets, and sponges, or these articles may be boiled in water and used damp after being wrung out of carbolic

or sublimate solution. They also may be sterilized in very small, separate packages, at the risk of scorching and burning, by dry heat in the oven of the kitchen range.

Position on the Operating Table.—The operating table should be well padded, and the patient placed in a comfortable position. If the back is not well supported, sacro-iliac strain may occur. If the arms are held above the head, brachial anesthesia may result; or if left hanging over the edge of the table, musculospiral palsy may follow. They may be fastened at the side of the body, or, for convenience, may be brought to the level of the neck. Great care should be taken that the patient is not burned by hot-water bottles during or immediately after the operation while under the anesthetic. As a rule, when the patient is returned to his warmed bed all hot-water bottles should be removed.

In *operations about the face or neck*, the hair should be covered by a rubber cap or snugly applied sterile towel. Frequently it is desirable to moisten it with 70 per cent. alcohol or, *if pediculi are present*, with ether. Infants and young children, for operations about the face and neck, should be given a papoose wrapping by being snugly rolled and pinned in a thin strong blanket with the arms against the sides.

As the patient is placed on the operating table, the operative field is widely exposed by the assistant nurse, and draped by sterile blankets or sheets which may be protected by sections of sterile rubber sheeting.

The *cleansed operative field* is now repainted with $3\frac{1}{2}$ per cent. tincture of iodin, and surrounded by sterile towels and sheets. After the incision is made, towels or pads are clipped over the wound edges so that no skin surface is exposed. Tinker and Sutton advise: Acriflavine, 5; acetone, 10; 50 per cent. alcohol, 90.

All sponges and pads are doubly counted before use, and recounted as the incision is closed. Sponges have even been left and overlooked under the scalp, and in relatively minor operations upon the breast and other parts. No method devised to prevent foreign bodies from being closed in wounds is fool-proof. Greater safety with less facility in use is obtained by using a continuous sponge (a long folded strip of gauze), sponges tied together by lengths of string, by having a metal ring attached by tape or string to each sponge or gauze pad or by introducing no sponge or pad into a wound not attached to an instrument. By sewing a metal figure in each pad the presence of a lost pad left in the body may be demonstrated by a Roentgenogram. It should be remembered that portions of gauze or rubber may become detached from drains and left in a wound. All instruments that may be left in the wound should also be counted.

The Patient.—Unless there is serious emergency, the patient should be carefully studied before operation. A detailed history should be taken and a thorough physical examination made, with investigation of the lungs, heart, kidneys, and general metabolism. By such a careful examination the diagnosis may be modified or amplified, and the operative treatment revised. If an operation is not imperative, it should be avoided during an acute respiratory infection, and in any case inhalation anesthetics are not to be used in any acute or subacute respiratory disease.

Preoperative treatment is most important. Failure to empty and cleanse the stomach or the bowel by preoperative treatment before it is opened at op-

eration may cost the life of the patient. In profound anemia the preoperative transfusion of blood, in dehydration the infusion of liquids, in toxic conditions the preoperative elimination and dilution of toxins, in jaundice the intravenous use of calcium, in exophthalmic goiter the feeding of iodin, in splenomegaly preoperation radiation of the spleen, in urinary retention the gradual decompression of the bladder may save the life of the patient. The infusion of liquids and glucose may enable a starved patient to withstand operation, and in any patient serve to protect the liver against the toxic action of ether. The bladder should be emptied immediately before any abdominal operation which may involve the pelvis. A hemoglobin percentage below 30 usually contraindicates operation.

Cardiovascular Disease.—Well-compensated valvular lesions of the heart not associated with vegetations or auricular clot rarely increase the danger of an operation. In mitral stenosis the clotted blood in the auricles greatly increases the danger of operation, and general anesthesia by a lipoid solvent, such as ether, should not be used. In forms of endocarditis with auricular clot several months of rest in bed to cause fixation of the clot may prevent a fatal postoperative embolism. Myocardial conduction disease, myocardial degeneration, coronary disease, aortitis, and aortic aneurysm greatly increase the danger of operation. Serious *myocardial insufficiency* is suggested by dulness over the posterior chest (*hypostatic congestion*), enlargement of the liver, edema of the extremities, and effort dyspnea. This syndrome contraindicates an elective operation. Cyanosis of the lips and finger-nails, and inability to hold the breath for thirty seconds (Stange's test, in which after a few deep inspirations the patient takes a deep breath and holds it as long as possible) are also ominous preoperative symptoms.

Before *operations upon the mouth*, the upper respiratory passages, esophagus, or upon stomach, the teeth should be cleaned and pyorrhea corrected, care being taken not to unbalance the bacterial flora in the mouth by too vigorous or irritating a treatment. A mouth wash of liquor antisepticus, diluted 1 part to 5 of water, may be freely used. The throat and nose are cleansed by instilling 25 per cent. argyrol, $\frac{1}{2}$ per cent. mercurochrome, or 1 : 5000 metaphen, or by a spray of warm boric acid or liquor antisepticus alkalinus.

With *pyloric* or *upper intestinal obstruction*, lavage should be done twelve hours before or, in an emergency, immediately before the operation, with $\frac{1}{2}$ of 1 per cent. hydrochloric acid in normal saline solution, continued until the washings return clear.

For *operations upon the rectum or lower bowel* a cleansing soap-suds enema is used, followed by irrigation with boric-acid solution. One-half of 1 per cent. hydrochloric acid in normal saline, or Condy's fluid may be used if an intestinal resection is to be done.

In *prostatic obstruction* with retention, at least ten days' preliminary treatment should be given, with gradual decompression of the bladder, the use of an indwelling catheter or, at times, a preliminary suprapubic cystostomy. The bladder should be irrigated daily with boric solution or a 1 : 5000 permanganate-of-potash solution, and daily instillations of 10 to 30 c.c. of 25 per cent. argento proteinum mite or similar non-irritating antiseptic used.

If the total phenolsulphonephthalein return is less than 20 per cent. or the urea-content of the blood-serum above 50 mg. per 100 c.c., operation should be delayed until the patient can be brought into better condition.

In obstructive and inflammatory conditions of the *gastro-intestinal tract and peritoneum*, the plasma carbon dioxid combining-power indicates alkalinosis or acidosis and is a guide to the treatment. Intestinal resection should, if possible, be delayed in acute obstruction, as the walls of the gut are then permeable to bacteria.

Preoperative Diet.—Coarse foods that leave a residue, or those that produce gas, should be avoided immediately before operation, particularly the coarser vegetables, fruit, milk, and the cereals containing cellulose. For an intra-abdominal operation, no food should be given within twelve hours. For a thoracic or peripheral operation, the patient may be given clear liquids up to four hours of the time of the operation.

Preoperative Purgation.—This should not be drastic and irritating. A 1-liter soap-suds enema, given twelve hours and three hours before operation, usually suffices. If the patient has been constipated, 30 or 60 c.c. of castor oil, a bottle of citrate of magnesia, or 1 ounce of Epsom salts may also be given the evening before operation. Laxatives by mouth are never to be used in acute inflammatory or obstructive conditions within the abdominal cavity.

Skin.—The patient should have a warm bath the evening before operation, and the operative field prepared by shaving and scrubbing with soap and water. This should be followed by alcohol, and a dry sterile occlusive dressing applied. Adhesive plaster, scabs, crusts, and epithelial scales should be removed by gauze wet with oil of wintergreen, turpentine, or ether. For the thick callous skin about the feet, a soap poultice may be applied for twelve to twenty-four hours, followed by thorough scrubbing and the application of alcohol.

Two hours before the operation the dry operative field (unless it involves mucous surfaces, the scrotum or vagina) is painted with a one-half strength ($3\frac{1}{2}$ per cent.) tincture of iodin, and covered by a dry sterile dressing. For persons with an idiosyncrasy to iodin, 2 per cent. picric acid in 80 per cent. alcohol may be used. For sensitive surfaces, such as the *scrotum* and *labia*, or in persons with a susceptibility to iodin, the skin should be prepared by soap and water, scrubbing and shaving, and the application of a 1 per cent. aqueous solution of mercurochrome, or metaphen 1 : 200, or a solution of bichlorid or oxycyanid of mercury 1 : 2000. *Mucous surfaces*, such as the vagina and rectum, are sterilized by scrubbing with soap and water, applying 2 per cent. of liquor cresolis compound in water, or by painting with a 1 per cent. aqueous solution of mercurochrome. Tincture of iodin is relatively ineffective on moist surfaces, so the skin should always be dried before it is applied.

The *conjunctiva* is cleansed by irrigation with saturated boric-acid solution, or the instillation of 1 : 200 solution of mercurochrome or 1 : 5000 metaphen, as is the *external ear* and *auditory meatus*.

In **gastric anacidity,** as with cancer, to reduce the bacterial content of the stomach, the patient should be given 10 minims of dilute hydrochloric acid in 60 c.c. of water, every two hours for twelve hours previous to the time of operation.

In an emergency no preparation is used, except the preparation of the skin of the field of operation and, if a general anesthetic is to be given or the stomach to be invaded, the emptying of the stomach.

Conservation of the Body Heat.—In the preoperative preparation and during the operation, the patient should be protected from exposure, chilling, cold solutions, and insufficient covering. Debilitated patients may have the legs, arms, and chest wrapped in cotton before being taken to the operating room, or be protected by appropriate warm leggings and shirt. In the operating room loss of heat should be prevented by having the table well padded, and the patient kept warm with blankets and protected hot-water bottles. Electric pads are dangerous, because when wet, they give off steam that may seriously burn the patient.

Exhausting preoperative examinations, especially those requiring starvation, physical or mental strain, the introduction into the body of toxic agents (as in cholecystography) or extensive radiation by Roentgen rays may prove the fatal additional burden for a debilitated patient subjected to a serious operation.

If such diagnostic procedures are necessary, the patient should be given time to recuperate before being subjected to the operation.

ROUTINE PREOPERATIVE TREATMENT

While the individual preferences of experienced surgeons vary widely, routine orders, such as the following, will protect the patient from many serious mistakes of omission or commission:

A. **Treatment for Operations Not Involving the Abdominal Cavity.**—1. Soft diet until 9.00 P. M. of the evening preceding the operation. If local or spinal anesthesia is used, water or tea without milk may be given the morning of the operation, except in B or C preoperative treatment. Avoid milk, cream, fruit (except orange-juice), and vegetables.

2. **Laxatives:** (a) *Castor oil* (60 c.c.) at 9.00 P. M. the day preceding the operation, followed by 1000-c.c. *soap-suds enema* three hours before the time of operation, or (b) 1000-c.c. *soap-suds enema* on the evening preceding, and the morning of operation.

3. **The Operative Area:** *General bath* on admission, followed the evening preceding the operation by: (a) Thorough *soap and water scrubbing* of the operative area; (b) *wet shaving*, and (c) *alcohol* (95 per cent.) *scrub;* followed by (d) dry occlusive sterile dressing, pinned or tied in place. Adhesive plaster or roller bandages will not be used. Towels or a large sterile pad may be used, and (for the leg, foot, or arm) a sterile bed-sock or towel. The part will be cleansed wide of the operative area, *i. e.:* For the hand, everything to the elbow; for the foot, to the knee; for the thigh, from the middle of leg to pelvis; for chest, the entire side of thorax, including lower neck and upper abdomen, and 10 cm. beyond median line front and back; for mastoid operation, shave and prepare area 20 cm. in diameter about ear, cleansing canal with warm 1 : 2000 mercury oxycyanid solution or a 1 : 200 mercurochrome, or 1 : 1000 metaphen. Special attention will be paid all skin creases or folds. The finger- and toe-nails will be trimmed short. For all operations below line of the nipple, the back below middorsal region will be similarly prepared for spinal anesthesia. For brain, shave and prepare entire head daily for three days preceding operation, if possible. For mouth, the teeth and mucous membrane will be scrubbed with cotton and 1 : 4 liquor antisepticus. For the nose, a spray of 1 : 2000 metaphen in normal saline.

4. **Sedatives:** One hour before operation (for adult) morphin sulph., gm. 0.01 (gr. 1/6) and atropin sulphate, gm. 0.003 (gr. 1/200) will be given by hypodermic injection except to toxic, uremic, or unconscious patients.

B. **For Operations Involving the Abdominal Cavity Without Evidence of Peritonitis or Other Infections.—Method.**—"A" will be used, except that no food or drink will be given after the laxative or within twelve hours of the time of operation. The entire abdomen will

be shaved and prepared, and the back prepared for spinal anesthesia. For operations on stomach or duodenum, no liquid will be given within twelve hours of the time of operation, or solid food within eighteen hours of operation. In pyloric obstruction, gastric retention, or intestinal obstruction with distended stomach, gastric lavage with 1 : 300 hydrochloric acid in normal saline solution will be used twelve hours before the time of operation.

C. **Treatment for Abdominal Operations With Peritonitis or Intestinal Obstruction.**—No food or drink, no laxatives on admission. If an immediate operation is to be done or the intestines have been damaged, no enema will be used. If the patient is senile or in bad general condition, no hypnotic hypodermic will be given. Unless otherwise ordered, an immediate preparation of the operative area will be carried out.

Preoperative Sterilization of the Skin.—Preferably one-half hour before operation, the dry operative field and field for spinal anesthetic will be painted with 3½ per cent. tincture of iodin, except the genitals, anus, mucous membranes, overhanging skin-folds. The iodin coat must dry, and will then be covered by a sterile dressing pinned or tied in place. Instead of iodin, a 2 per cent. solution of picric acid in alcohol may be used. In an emergency the skin will first be carefully cleaned with ether upon gauze wipes. For the vagina, a douche of 2000 c.c. of a 2 per cent. solution of liquor cresolis compound will be used, both the night before and on the morning of the operation. This solution is also used to irrigate the rectum and anus. For the male genitals, alcohol or other irritating solution will not be used; the parts being painted (after being thoroughly cleansed with soap and water and dried with a sterile towel) with a 1 : 2000 mercury-oxycyanid solution, 1 : 200 mercurochrome, 1 : 1000 metaphen, or 1 : 1000 hexylresorcinol in 30 per cent. glycerin solution.

For all abdominal operations the bladder will be emptied by a catheter immediately before the operation, if the patient cannot void.

POSTOPERATIVE TREATMENT

A. **Treatment. For Operations Not Abdominal.**—1. **Diet:** Water as desired, as soon as anesthetic nausea subsides, liquid diet after twelve hours; soft diet after forty-eight hours.

2. **Sedatives:** Morphin sulphate by hypodermic, gm. 0.01 (gr. $\frac{1}{6}$), every three hours for pain, as required, during first twenty-four hours.

3. **Laxatives:** Magnesium sulphate, 15 c.c. every six hours, or 1000-c.c. soap-suds enema, beginning forty-eight hours after operation, except in hemorrhoids—give castor oil, 30 c.c., seventy-two hours after operation.

4. **Dressing:** For hemorrhoids, wash with 1 : 4000 sublimate solution, and apply boric acid ointment two or more times daily and after each bowel movement. Small drain tubes will be removed in twenty-four to forty-eight hours, large drains and packs in seventy-two to ninety-six hours, or after the fourth day in streptococcic infections. For serum or bloody oozing, they should be removed in twenty-four to forty-eight hours; for thin pus, in forty-eight to seventy-two hours; for thick pus and necrotic masses, fourth to seventh day. For a Mikulicz drain, gradually remove contents of the bag beginning after forty-eight hours, the bag being finally removed on the fifth to eighth day.

B. **Treatment. For Clean Abdominal Sections.**—1. **Diet:** Sips of warm water or barley water as soon as operative nausea subsides. Liquid diet after twelve hours unless nauseated. Light soft diet after bowels have freely moved.

2. **Sedatives:** Morphin sulphate, gm. 0.01 (gr. $\frac{1}{6}$) by hypodermic, every three hours for pain or cough, if required, during first twenty-four hours only. For gas-pain a 500 c.c. milk-of-asafetida enema, with hypodermic of surgical pituitrin (1 c.c.), and a mustard plaster or hot-water bottle to the epigastrium.

3. **Laxatives:** An enema of warm water (240 c.c.) every four hours for the first twenty-four hours, beginning with return from the operating room; at end of twenty-four hours, reduce enema to 120 c.c., and add 15 c.c. magnesium sulphate. If no evacuation after fourth small enema, give four hours later, by enema: warm milk, 90 c.c.; black molasses, 90 c.c. Thereafter soap-suds enema is given daily as required.

4. **Position:** After twelve hours, turn on the side once every sixth hour. *Back-rest:* Clean appendectomy, third or fourth day; gastric or biliary operation, first day; hernia, tenth to twelfth day; pelvic operation, seventh to tenth day. A patient, after an aseptic appendectomy with grid-

iron incision, is permitted to be out of bed on the fourth to sixth day; gastro-enterostomy, tenth day; herniorrhaphy, twelfth to fourteenth day. No patient is to be permitted up if wound is indurated, suppurating, painful, or if there is fever. After being up two to seven days the patient is usually discharged from the hospital.

5. **Dressing**: First dressing is made on the seventh day, or on appearance of fever. Snugly supporting outside bandage will be maintained if patient develops cough or is restless. If wound has been united under tension, sufficient supporting sutures will be left until fourteenth day, and ample adhesive strapping used. For wound infection or induration, dress daily with a 2 per cent. yellow-oxid-of-mercury ointment. Instead of packing wounds, sinuses are gently filled with bismuth subiodid paste from a syringe.

C. **Treatment. For Septic Abdominal Section.**—1. **Diet**: No food or water whatsoever. Mouth-wash of plain water is used as desired. If there is marked nausea, gastric lavage will be used (with hot water, 500 c.c.; sodium bicarbonate, 3 gm.) by tube or by swallowing. For persistent regurgitation a Jutte tube will be inserted and retained. Sips of warm water, barley water, or weak tea (4 c.c. every one-half hour) will be started on the fourth day and increased, *provided the bowels have moved freely, flatus is being expelled*, and *all nausea has ceased*, to be immediately discontinued if pain, nausea, tympany, or fever follows.

2. **Sedatives**: Morphin sulphate, gm. 0.01 (gr. $\frac{1}{6}$ or $\frac{1}{8}$) by hypodermic, every three hours, only if urgently required for pain during first twenty-four hours. *Omit if possible.*

3. **Position**: Fowler's position immediately, except after spinal anesthesia when there should be a delay of one-half to two hours.

4. **Elimination and Dilution of Toxins**: Continuous hypodermoclysis through two small rustless needles, introduced in the submammary space, with the introduction of 1000 to 6000 c.c. of decinormal saline solution daily, while pulse is above 100 or the patient shows evidence of dehydration or alkalinosis. The reservoir will be elevated to a height to produce a moderate local edema only, and the flow controlled by gravity and not by a device on the tube. Discontinue on evidence of pulmonary edema.

5. **Laxatives**: *Enemas as in treatment "B,"* started only after there is evidence of localization of the infection.

6. **Dressing**: First in forty-eight hours if drainage case, afterward as required.

7. Glucose solution or typed blood will be given intravenously in conditions of marked gravity.

Proctoclysis or *retention enema* (solution consists of glucose, 100 gm.; salt, 20 gm.; water, 1000 c.c.) is to be used in all cases of shock, asthenia, dehydration or deep narcosis, unless an enema is contraindicated by operation on the lower bowel or by peritonitis.

Immediate Postoperative Treatment.—**Shock, asthenia,** and **dehydration** are to be treated by rest, warmth, and the introduction of fluids and nourishment by mouth, rectum, subcutaneous tissues and blood-vessels, as has been described under their respective headings.

Secondary shock or **delayed postoperative shock** requires instant attention, and should immediately be treated as one of postoperative hemorrhage until this dreaded complication is absolutely disproved. Usually an immediate reopening of the wound and arrest of bleeding is necessary, and should not be delayed. When a plaster case has been used the possibility of ischemia and gangrene under the case is to be considered.

Postoperative stupor or **coma** should be investigated as to cause. Often it is due to the excessive use of opiates or narcotics, especially in the elderly or enfeebled patient, but it may be due to acidosis (diabetes), uremia, or hemiplegia from cerebral hemorrhages or embolism. The patient should constantly be watched, the tongue held forward to prevent suffocation, and treatment appropriate for the underlying condition instituted.

Postoperative excitement, or **delirium,** or **mania** often is due to the use of opiates—as morphin, hyoscin, scopolamin—especially in elderly patients with

limited renal or hepatic function. Death may follow attempts to quiet these patients by giving additional opiate. The treatment used should favor the dilution and elimination of toxic substances in the body. The excitation or delirium from wound infection, renal or hepatic disease, diabetes, thyroid crisis, psychosis, or chronic alcoholism should be differentiated and appropriately treated, as described in the chapter on Delirium.

Postoperative pain should not be treated by the routine use of opiates. After the first twenty-four hours, the pain usually will be found to be due to some complicating condition. If the area of the wound is painful, it should be examined for retained blood or serum, infection, or separation and protrusion of viscera.

Abdominal pain from gas distention, or gastric retention is to be relieved by lavage, or a rectal tube or enema. *Lower abdominal pain* suggests retention of urine, as does incontinence of overflow. Rectal and pelvic pain are not infrequently due to fecal impaction. An abdominal, rectal, or vaginal examination should be made, and a catheter used if there is evidence of distention of the bladder, or gas and fecal matter evacuated if the lower bowel is distended.

Postoperative pain after the reduction of a fracture suggests an overlooked dislocation, a tight bandage, an improper position of fragments, or some wound complication to be ascertained and relieved.

Restlessness and *insomnia* are often best relieved by an efficient nurse. A change or rearrangement of bed clothing, a more comfortable position, a hot sponge-bath, an alcohol rub, gentle general massage, a cup of hot gruel, the skilful use of hot-water bags or an ice-cap, and the use of an enema or catheter, are simple but frequently neglected measures that give comfort and sleep. The personality of the nurse or of visitors may irritate or stimulate the patient. Such causes of restlessness as poorly selected, indigestible, or insufficient food, or stimulants as tea, coffee, or condiments should be eliminated. Often the revision by the surgeon of a badly applied or displaced dressing gives comfort. In all cases, unless there is a hopeless, ineradicable affliction the continued use of opiates is a reproach to the medical and nursing attention given the patient. For the neurotic or irritable patient who demands medication the simple harmless sedatives—as valerian, asafetida, sumbul, hops, catnip; in elixir, pill, or other form—should first be considered. Occasionally and for short periods, bromids, chloral, chlorbutanol, or Hoffmann's anodyne may be tried, or for transient use—remembering that the continued use of any coal-tar derivative is harmful to the organism—acetylsalicylic acid, sulphonethylmethanum (trional), barbital, allonal, or similar hypnotic may be used as preferable to morphin.

Hiccup often persists for days and is difficult to overcome. Any one of the following treatments may appear to be effective or, more frequently, useless. The surgeon therefore often will try one method after another. (a) *Repeated gastric lavage*, with warm water containing 4 gm. of sodium bicarbonate to each liter. (b) *Venoclysis*—200 to 500 c.c. of 20 per cent. glucose in saline. (c) *Tincture of musk* or *tincture of myrrh*, 4 c.c. in 60 c.c. water, given every one-half hour. *Tincture of ipecac*, 5 minims every twenty minutes for 4 doses. (d) *Massage* (general and over the phrenics). (e) *Tight abdominal binder*, forced flexion of the thighs on the abdomen; *mustard plaster* or blister to epigastrium.

(f) A *pinch of table salt* or sugar dissolved on the tongue. (g) One drop of *tincture of iodin* in a teaspoonful of water, every fifteen minutes for six doses. (h) *Ice* on the tongue. (i) *Lemon juice, orange juice*, 1 teaspoonful every twenty minutes. (j) *Drinking water* while holding the breath. (k) *Elimination* and *cathartics* if not contraindicated. (l) *Solid food*, as crackers or dry toast. (m) *Sedatives*, as: Hoffmann's anodyne, 1 teaspoonful on cracked ice; chloral hydrate, 1 gm.; chlorbutanol, 0.5 gm.; or bromids, 1 to 3 gm., by mouth or rectum. (n) *Epinephrin*, 10 minims of the 1 : 1000 solution, subcutaneouly. (o) *Opiates* are to be avoided, if possible, and elimination promoted.

In Sepsis Consider:

1. *Dilution of toxins:* Murphy drip, hypodermoclysis (continuous or intermittent), transfusion.
2. *Elimination:* Hot packs, electric-light bath, warm alcohol sponges (avoid opiates as a rule).
3. *Alkalinization:* Sodium bicarbonate, calcium, sodium citrate.
4. *Drainage*, aided by heat, moisture, dependency, capillary attraction.
5. *Antidotal measures:* Serums and vaccines, calcium lactate or chlorid intravenously, extracts of ductless glands.
6. *Support of patient*, easily assimilable food, iron, digitalis.
7. *Rest*, general and local. Avoid manipulation, squeezing, milking, palpating, massaging the affected part.

In Shock Consider:

1. *Rest, warmth.*
2. *Nourishment:* Introduction of liquids—stomach, rectum, under skin, intravenously.
3. *Transfusion:* (a) Autotransfusion. (b) Homologous by donor. (c) Extremities compressed by Esmarch.
4. *Position*—head low.
5. *Opiates* (cautiously).
6. *Hemorrhage*, internal.
7. *Operation* to be delayed, if possible, until reaction occurs.

Internal Hemorrhages:

1. *Complete rest*, local and general.
2. *Elevate bleeding part* (Fowler's position).
3. *Measure blood coagulability:* 300 c.c. of 2 per cent. calcium chlorid intravenously; 10 to 20 c.c. thromboplastin subcutaneously, or 20 c.c. horse-serum subcutaneously? (Urticaria, anaphylaxis.)
4. *Ice-bag* over affected part.
5. *Hemostatics:* (a) If intra-abdominal, pads and very tight bandage to increase intra-abdominal pressure. (b) Tannic acid gr. x to xl, turpentine ♏xxx in emulsion, Monsell's solution, adrenalin ♏x, if part can be directly reached by drug. (c) Ergot ʒii, gallic acid gr. xx, turpentine ♏xxx, if part is to be reached through blood-stream.
6. *Maintain low blood-pressure*, cord extremities, avoid stimulants, favor syncope.
7. *Early operation*, usually of first importance.

Suture Removal.—All sutures should be painted with tincture of iodin before removal.

1. *Michel clips* are removed in forty-eight hours.

2. *Coapting* horse-hair and dermal sutures, any time after the third day. *To avoid scarring* (on face), on the third day.

3. *Approximating* and *tension sutures* are removed from the seventh to the fourteenth day, dependent on healing and tension. In the abdomen or loin, alternating sutures will be removed on the seventh day; the remainder on ninth or tenth day. If there is much tension, as after lipectomy or radical amputation of breast, at least every third suture should be left until the fourteenth day.

Drain tubes, fixed catheters and the like, if protruding from dressing, should have the outer end continuously immersed in 2 per cent. liquor cresolis compound to prevent an ascending infection.

Dressings should support and protect, but not constrict. They are to be renewed each week or whenever loosened. In biliary, pancreatic, gastric, or intestinal fistula: Remove all dressings; keep the skin dry and coated with zinc stearate, and exposed to an electric light under a cradle.

Supporting bandage and adhesive strapping to maintain a snug support should be continued, after clean appendectomy, for one month; after herniorrhaphy, for six weeks; after a large, clean abdominal section, for six weeks; after varicose veins of the leg have been removed, for six or more weeks.

Continued support by soft truss, belt, specially fitted bandage, supporter, elastic girdle or supporting corset is to be maintained after abdominal operations when patient is: (1) Very obese. (2) Has had drainage or suppuration in the wound. (3) Has had a lipectomy or unusually large herniorrhaphy. (4) Is subject to unusual strain from attacks of coughing, epilepsy, vomiting, or the like.

Patient May Resume Light Work:

1. After *simple appendectomy,* in from two to three weeks.

2. After *drainage operation* on abdomen, in two months after complete healing.

3. After *herniorrhaphy,* light work in six weeks, heavy work in three months.

4. After *cholecystectomy,* in six weeks.

5. After *gastro-enterostomy,* in six weeks.

6. After *partial gastrectomy,* in two to three months.

Postoperative Diet.—Directions to be given to the patient modified by conditions present in the particular case.

After Leaving Hospital.—Eat slowly, masticate thoroughly, when relaxed and with pleasant surroundings.

Soups: Only clear, non-greasy soups or purées; not highly seasoned.

Fish: Oysters—raw, stewed, or panned. Fish—broiled, baked, or planked—except shad, mackerel, and blue-fish.

Cereals: Gruels, with barley flour or arrowroot, cornmeal mush, cracked wheat, puffed rice or wheat, boiled rice, cream of wheat, zwiebach, toast, educator or water crackers, bread (well baked and dried out).

Vegetables: Spinach, lettuce, celery, endive, broccoli, purée of corn or peas.

Eggs: Boiled, poached, or soufflé.

Meat: Lamb, beef, chicken, squab, sweetbreads, brain—broiled, roasted, or planked—sliced baked ham.

Fats: Butter, roasted beef fat, olive or cod-liver oil.

Fruit: Oranges, apple-sauce, baked apple, stewed pears and peaches.

Desserts: Junket, custard, gelatin jelly, cornstarch pudding, arrowroot, blanc mange, tapioca, plain vanilla or chocolate ice-cream, light sponge cake, angel food.

Beverages: Milk with lime-water, Vichy, weak tea, malted milk, cereal coffee, cocoa (not rich), buttermilk, plain or carbonated waters, diluted grape-juice or orange-juice.

After *gastro-enterostomy*, additional light meals should be taken at 10 A. M., 4 and 10 P. M.

After *gastrectomy*, six small meals daily.

After *gall-bladder operations*, limit or avoid meats.

With *high-grade anemia*, liver should be eaten daily.

Avoid—*Fish:* Lobsters, crabs, clams, or fried fish.

Meats: Pork, veal, corned beef, sausage, scrapple; fried, stewed, fricasseed, pickled, spiced meats; dumplings, meat pies.

Cereals, *vegetables*, and *fruits:* Cabbage, corn, string-beans, egg-plant, stewed tomatoes, cucumbers, pickles, radishes, greasy soups, raw pears, apples, bananas, nuts, melons.

Condiments: Chili sauce, Worcestershire sauce, vinegar, mustard, horse-radish, tomato catsup.

Drinks: Coffee, soft drinks, green beer, or near beer.

Continue Diet: After *simple appendectomy*, three weeks.

After *herniorrhaphy*, two weeks.

After *septic appendectomy*, two months after complete healing.

After *gall-bladder operation*, six months.

After *gastro-enterostomy*, six months after complete relief from symptoms.

After *gastrectomy*, twelve months after complete relief from symptoms.

Post-operative constipation should be overcome by:

1. **Regular morning habit**, which should be cultivated daily.

2. **Diet:** (a) *Glass of cold water*, containing a teaspoonful to a tablespoonful of uncooked cornmeal, on arising. (b) Use of *cereals* containing bran or cellulose, as bran breakfast food, Uncle Sam's breakfast food, cracked wheat, cornmeal, Wheatena, Pettijohn. (c) *Laxative Foods:* Bran bread, Graham bread, corn bread, beans, peas, celery, lettuce, squash, turnips, New Orleans molasses (if there is no tendency to flatulence), apples, figs, dates, nuts.

3. **Daily enema** of 1000 c.c. (1 quart) water and 2 teaspoonfuls salt, or a gluten suppository on arising.

4. **Medicaments** are to be avoided if possible, but may be needed in the early weeks and months after operation. The following may be used: *Mineral oil*, 1 teaspoonful to 1 tablespoonful after meals, two or three times daily. *Cascara sagrada* or *buckthorn*, 0.3 to 1 gm. of the extract or 10 to 40 drops of the fluid-

extract to be taken on retiring. *Compound licorice powder*, 1 teaspoonful (more or less as required) on retiring. *Laxative pill* on retiring, especially the *Lady Webster pill* (*pill of aloes and mastic*), the *lapactic pill*, or the *Hinckle formula*.

After *operations on the biliary system*, Carlsbad salts or sodium phosphate, 1 teaspoonful or more to be taken in hot water before meals, is useful. Sodium succinate or salicylate, 0.3 gm. taken after meals, is used for the residual cholangitis or cholecystitis.

For *gastric acidity* with constipation, a tablet or powder of rhubarb, soda, and cascara, taken after meals, is often very helpful.

The continued use of salines, drastic purgatives, and laxatives containing phenolphthalein should be avoided.

CHAPTER XXIX

OPERATIVE AND PLASTIC SURGERY

The **instruments used in operations** include:

A. **Knives for the Sharp Division of Tissue.**—The chief varieties are:

1. *Scalpels*, which have short, usually bellied blades and are used for general operative work. The point is either (a) near the axis of the back of the handle, or (b) in the axis of the handle (*center point*).

2. *Bistouries*, which are long narrow knives used for puncturing or for cutting from within out. Bistouries are straight or curved, sharp or probe-pointed. The *herniotome*, formerly used to divide the ring of a strangulated hernia, is entirely blunt except for about 2 cm. of cutting surface well back from the end. A *meatotome* is a ball-pointed bistoury used for meatotomy. Bistouries are rarely used except to incise abscesses or to open sinuses or fistulas.

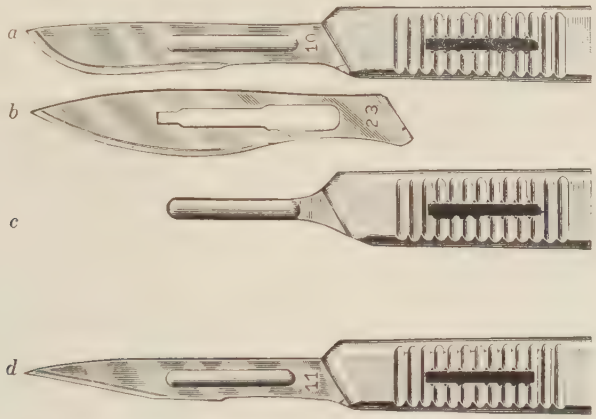


Fig. 412.—Operating knives with detachable handles: *a*, scalpel; *b*, center point scalpel; *c*, detached handle; *d*, short straight bistoury.

3. *Tenotomes*, which have a very small narrow blade on a long slender shank, are used for subcutaneous tenotomy.

4. *Cartilage knives*, which are short, very strong and heavy knives, occasionally employed for cutting resistant tissues as in operations upon bones and joints.

5. *Lancets*, which are short, usually double-edged puncturing knives, formerly much used for phlebotomy. The *gum lancet*—with a short blade projecting nearly at right angles to the shank, devised to divide the gum to aid the eruption of teeth—is now rarely used.

6. *Amputating knives*, which are large, long, usually pointed knives. The best known are *Liston's large* and *Liston's small amputating knife*. The *catlin* (large, medium, and small) resembles an amputating knife, but is double edged. It was esteemed, in preanesthetic days, to quickly divide tissues between con-

tiguous bones during an amputation. As accuracy is now more important than great speed, amputating knives have largely been supplanted by the scalpel.

B. **Instruments for the blunt division of tissue**, or division by crushing or blunt separation:

1. *Écraseur*, a powerful instrument for dividing tissue by crushing with a chain, cable, or heavy wire, is now obsolete.

Fig. 413.—Liston's long amputating knife.

Fig. 414.—Catlin.

2. *Serrenœud*, a similar instrument, with a constricting loop left attached to the tissues to arrest hemorrhage, was formerly used in hysterectomy to compress the uterine pedicle. Except by the relatively delicate *snares* used for the removal of tonsils, mucous polyps, and similar growths, division of tissue by crushing is now rarely used in human practice.

3. *Snares* are divided into: (a) The *cold snare*, (b) the *hot snare*—the wire, being heated by an electric current, becomes a constricting cautery loop.

4. *Elastic* or *twine ligature* serves to slowly divide tissue with little hemorrhage. A tightly tied cord of elastic rubber or linen is used. The method has been employed to avoid hemorrhage in opening a deep fistula in ano, in doing gastro-enterostomy (*McGraw's elastic ligature method*, *Maury's twine method*), to strangulate hemorrhoids and pedunculated growths, and to do a cholecystoduodenostomy with the gradual release of the biliary pressure in the presence of intense jaundice (Babcock).

Fig. 415.—Mayo dissecting scissors.

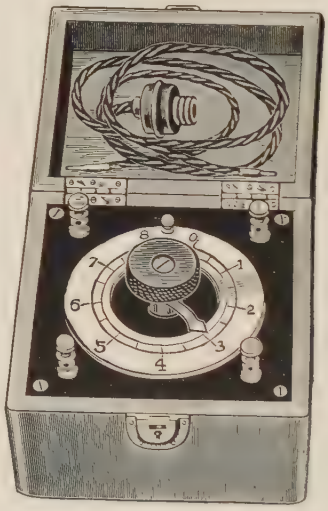


Fig. 416.—Lentz-Downes heavy cautery transformer and rheostat with miniature light as indicator.

5. *Blunt dissectors* are knife-shaped instruments with thickened, dull edges for the blunt separation of tissues. Those of *Allis* and *Kocher* are best known, but as blunt dissection is readily carried out by a knife handle, blunt scissors' points, or hemostatic forceps, and as the surgeon should avoid, as far as possible, the traumatism of blunt separation in the division of tissue, these instruments are not essential.

C. **Division or Destruction of Tissue by Heat (Cauterization).**—1. *Paquelin cautery*, with heat produced by the vapor of benzin acting on platinum sponge

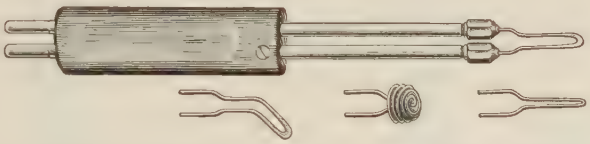


Fig. 417.—Lentz-Downes heavy cautery handle with interchangeable tips.

in the blade or cautery point, which replaced the ancient cautery irons heated in a brazier or flame, has in turn largely been supplanted by the electric cautery. The ordinary soldering iron has often been used as a cautery. At a red or white heat, the actual cautery rapidly divides the soft tissues with free hemorrhage; at a very dull red or black heat the tissues are seared and condensed with arrest of hemorrhage. For hemostasis the lower degrees of heat should therefore be used. In the *Percy electric cautery (cold iron cautery)* an attempt is made to heat the tissues sufficiently to destroy neoplastic but not normal cells.

Fig. 418.—Liston's bone-cutting forceps modified, double action.

Fig. 419.—Liston's curved on the flat bone-cutting forceps, double action.

2. *Radio knife*, using a fine wire loop and a high-frequency current, so rapidly divides tissue and with such limited superficial destruction that, while hemorrhage is reduced, primary union may occur after suture of the edges of the wound.

3. *Atmocausis*, cauterization by means of steam, has been used in the uterus. Like cauterization by a jet of flame it is not easily controlled and has had a very

limited vogue. The boiling oil poured into the wounds of war in the time of Paré, while barbaric, served to check bleeding, and probably reduced the incidence of gas gangrene and tetanus.

D. **Bone-cutting Instruments.**—1. *Bone-cutting forceps:* The best known are *Liston's straight* and *Liston's curved on the flat bone-cutting forceps.* To increase the fulcrum and power, these forceps are made with double joints or long handles.

2. *Costotomes* are bone-cutting forceps designed for the division of ribs, and include *Gluck's* and *Stille's costotomes.*

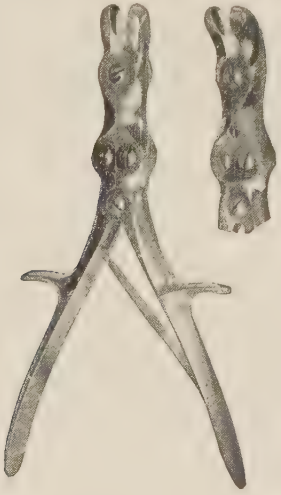


Fig. 420.—Double action bone rongeur.

Fig. 421.—Bone-cutting forceps.

3. *Rongeurs* or bone-gouging forceps are used for biting out portions of bone, especially of the skull. *Hoffman's* and *Luer's rongeurs* are in common use. The instrument of *Dahlgren* is valuable where a more powerful rongeur is required. The *DeVilbiss rongeur* cuts a narrow slot in the skull, and is used when it is desired to later replace the bone that has been removed.

Bone-holding forceps are used to grasp the larger bones of the body, the best known being *Ferguson's lion-jaw bone-holding forceps, Farabeuf's forceps,* and the

Fig. 421*a*.—Raspatory.

long bone-holding *forceps of Lane.* Smaller pointed forceps, like that of *Van Buren* and *Hamilton*, used for the removal of small or detached particles of bone are called *sequestrum forceps.*

Periosteal elevators are used for the separation of periosteum. *Raspatories* with a sharp or serrated edge, used for scraping away the periosteum, were formerly often combined with periosteal separators.

4. *Saws* are used for the division of bone, and may be hand or power driven. Conventional types are *Charrier's* saw and *Satterlee's* saw, used for the division of the larger long bones. Small narrow saws, *metacarpal saws* and *nasal saws*, are used for the division of the smaller and more delicate bones. The hack-

and fret-saws of the hardware stores are inexpensive and efficient substitutes. *Hey's saw* was formerly employed upon the skull.

Flexible Saws: The older *chain-saw* has been replaced by the more slender and manageable wire-saw or *Gigli saw*. For introducing the Gigli saw under the skull *Schaefer's wire saw-carrier* is helpful. A dural protector, which may be improvised of a metal corset-steel, is used as the bone is divided.

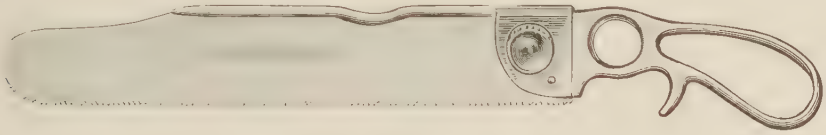


Fig. 422.—Charrier's saw.

5. *Drills* serve to make holes in bone, and are of two types: The *small drills* form narrow channels for the introduction of ligatures, screws, or bolts. The *large rose-headed burs* produce larger openings, and penetrate the skull without damaging the dura or brain. Of the larger burs, those of Doyen and the modifications by Hudson and Cushing are the best known. *Trephines* are crown saws used to remove circular disks of bone, especially from the skull. The

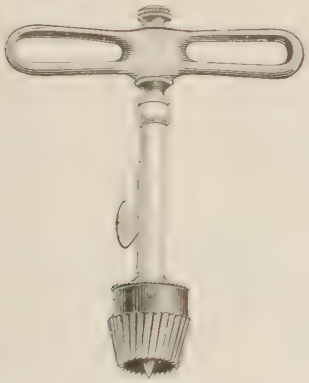


Fig. 423.—Galt's trephine. The instrument is actuated by alternating semicircular turns of the wrist to the left and right. As soon as a circular groove has been formed in the skull the center pin is withdrawn.

Fig. 424.—Heavy volsellum forceps.

conical trephine (Galt's trephine), shaped like a truncated cone, becomes wedged in the opening when the skull is penetrated and therefore is safer than the cylindrical crown trephine. Trephines have been largely replaced by the safer perforating burs.

6. *Probes*, slender, blunt-pointed, flexible, wire-like instruments designed for the exploration of wounds, sinuses, and cavities, are much less frequently used than formerly. The large aluminum probe of *Fluhrer* is occasionally used in the brain.

7. *Tenacula* consist of a sharp hook upon a long handle, and are used for holding tissue. *Tenaculum forceps* have a scissors' handle, and long blades termi-

nating in short sharp hooks. *Volsellum forceps* resemble tenaculum forceps, but have more than a single tooth upon each blade.

8. *Chisels* are used for the division and contouring of bone, only one side of the blade being beveled.

Osteotomes resemble chisels, but the blade is equally beveled upon both sides. They are used for the simple division of long bones.

Grooved directors are narrow blunt instruments with a groove or gutter to guide a cutting blade. They were esteemed by a former generation of surgeons, but are now only occasionally used as probes and to facilitate the escape of liquids from wounds, replacing the old grooved needle.

Curets are sharp or dull spoon-shaped instruments for scraping away soft or hard tissue.

E. **Forcipressure.**—*Arterial forceps, hemostatic forceps, hemostats* of the most useful type have scissors' handles and snap catches, and are best made of chrome (rustless) steel with a box lock. The following varieties are most desirable:

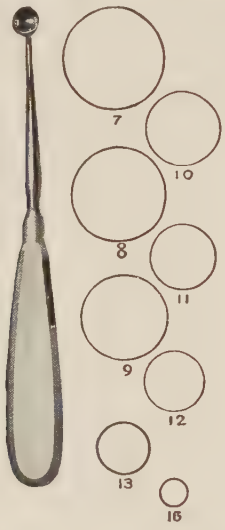


Fig. 425.—Bruns' bone-curet, showing various sizes of spoon.

Fig. 426.—Kelly-Péan forceps, curved.

(a) *Curved Kelly-Péan forceps* which will serve as pedicle clamps or artery forceps, and are the most useful general abdominal hemostatic forceps. (b) *Kocher's forceps* are valuable general operative forceps. The jaws are straight, serrated, and have two teeth at the end of one jaw and one on the other, giving a firm hold on the tissues. When over 6 inches in length they are often called *Ochsner's forceps*. (c) *Halsted's straight artery forceps*, and the finer, (d) *Halsted's mosquito forceps*, are useful in delicate dissections. (e) *Ferguson's forceps*, which have powerful, wide, short serrated blades, are occasionally of value when a crushing effect is desired.

The many other hemostatic forceps have few outstanding advantages over the five mentioned.

Serrefines are diminutive spring artery clips now obsolete.

Tissue and *dressing forceps* are spring forceps with plain, serrated, or mouse-

tooth jaws. For general operative work, a forceps with delicate teeth and spring shanks that will hold without crushing the tissue is preferred. *Splinter forceps* have delicate fine points for introduction into the tissue and the removal of foreign bodies.

Fig. 427.—Kelly hemostatic forceps, straight and curved.

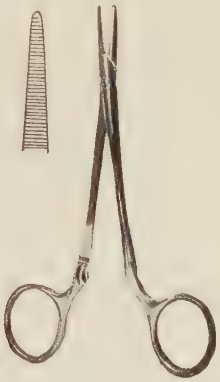


Fig. 428.—Halsted's delicate mosquito hemostatic forceps used in plastic surgery.

F. **Retractors** have sharp or dull blades.

1. *Dull Retractors:* For the larger abdominal wounds, the retractors of *Kelly;* for the smaller abdominal wounds, those of *Richardson* or *Crile* are desirable.

2. *Sharp Retractors: Volkmann's* sharp retractors have from one to six

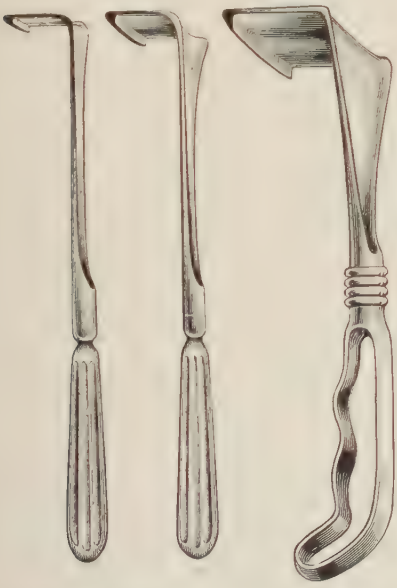


Fig. 429.—Abdominal retractors, small, medium, and large.

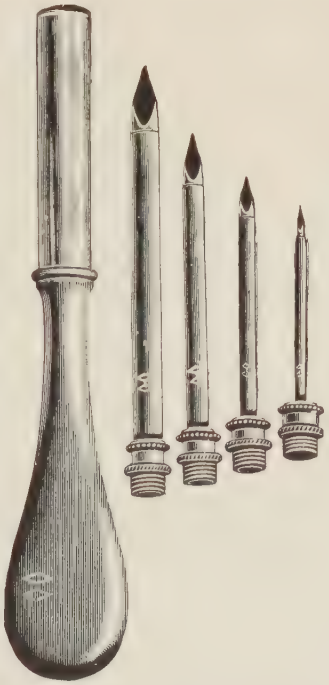


Fig. 430.—Set of trocars with handle.

prongs. *Halsted's* sharp retractors have short angular teeth and are useful in herniorrhaphy and in superficial wounds when strong traction is unnecessary.

3. *Specula* are used for the exploration of cavities and openings of the body and may be (1) *tubular*, with or without an obdurator, or (2) *valvular*, either (a) with a single valve or (b) bivalved or (c) trivalved.

G. **Trocars** consist of hollow metal tubes (cannula) within which a snug-fitting sharp-pointed removable puncturing mandrin or trocar is fitted. Trocars are used for the evacuation of liquids from cavities.

H. **Needles** vary in size from the minute needles used for arteries (*Carrel's straight and curved*), the eye, or cleft-palate (*Lane's straight, curved*, and *half-circle needles*) to the large postmortem needles. According to the degree of curve, the needles are classified into: Half-curve, full-curve, extra-curve, half-circle, oblique-curved, and three-eighths circle. Needles are occasionally mounted in the handles, as with staphylorrhaphy, cleft-palate, or tonsil needles. Needles are numerically graded from 1 to 13, the higher numbers representing the smaller sizes.

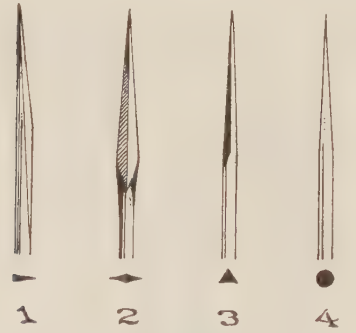


Fig. 431.—Types of needle points on surgical needles: 1, Single cutting edge used on the Hagedorn needle. 2, Double cutting edge or spear point. 3, Triangular cutting or trocar-pointed needle, valuable in penetrating tough tissues, as the skin. 4, Tapered, round, non-cutting point as in the cambric needle used in gastro-intestinal suture, the suture of blood-vessels, nerves, and the softer tissues.

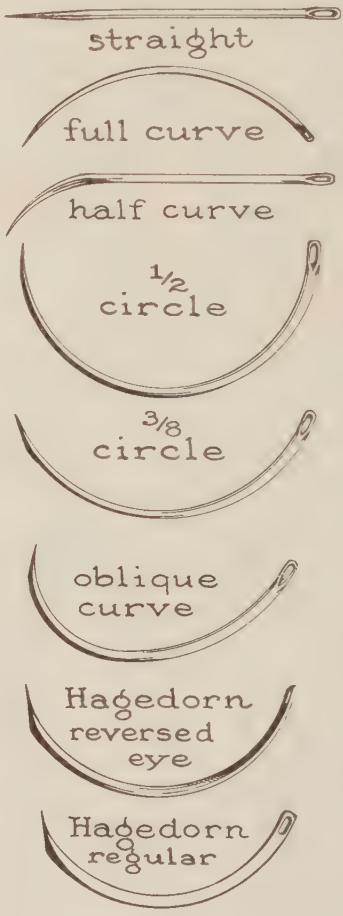


Fig. 432.—Types of surgical needles.

1. *Round-pointed needles* without cutting edge are used where it is desired to have the needle puncture but not cut the tissue, as with the alimentary tract, the softer viscera and tissues (muscle or fat); for blood-vessels, and the sheaths of peripheral nerves. For the suture of delicate blood-vessels, nerve sheaths, and thin membranes fine bead threading needles (size 8 to 12) or fine curved needles are used. For the intestinal tract and serous membrane, cambric needles (as

used by the seamstress) are employed, or half-circle needles of the same type. For coarser tissue (as muscle or loose fascia) full-curved needles, as Ferguson's round or taper-point needles, are valuable. Large blunt-pointed needles, either curved or straight, are used for suturing the liver.

2. *Cutting-edge needles* are used for the skin and more resistant tissues, which the needle both punctures and cuts. The point may be (a) *triangular* or *trocar-pointed*, with three cutting edges, (b) *lancet-pointed*, with two cutting edges, or (c) with an *oblique chisel-edge*, as with the flat Hagedorn needle. In sewing the skin the trocar-pointed needle is most efficient, although, when very

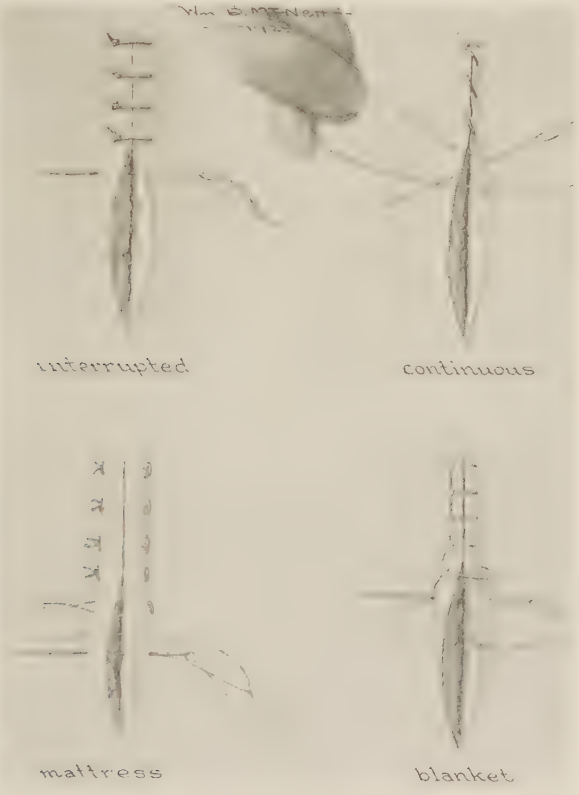


Fig. 433.—Interrupted and continuous sutures.

large needles are employed, the lancet- or chisel-point divides the skin better. For general work, especially in suturing fascial and aponeurotic planes in deep wounds, the Kelly oblique-curve cutting-edged fistula needle is very useful.

3. *Aneurysm needles* are blunt pointed, curved, in a handle, with the eye near the point. *Reverdin's needle* is lancet pointed, mounted upon a handle, and has an eye near the point that is opened by moving a lever at the base of the handle. It is popular with French surgeons.

The *aneurysm needle*, and the *transfixion* or *pedicle needle*, or *ligature carrier* may be eliminated without detriment from the operating set. A curved needle held in a needle-holder and used blunt end first is a satisfactory substitute.

Sutures are fine cord-like structures used to coapt tissues. They should be so used that they will not constrict, cause necrosis, or do other damage to the part.

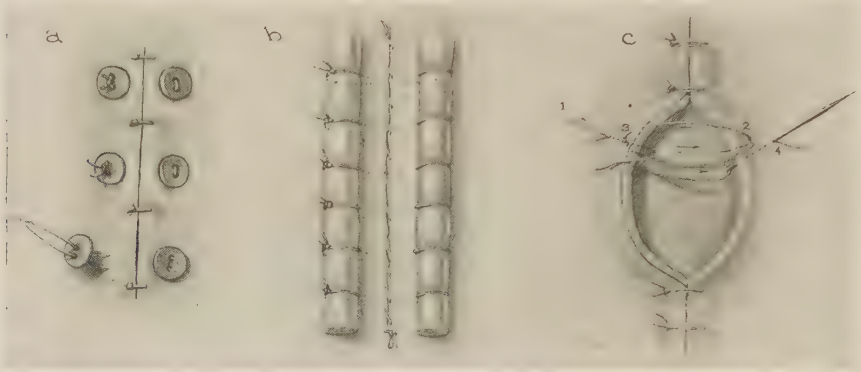


Fig. 434.—Relaxing sutures: *a*, Button sutures and intermediate, interrupted coapting sutures. The button may cause pressure-necrosis of the skin. *b*, Vertical mattress-sutures tied over dental cotton rolls with coapting fine continuous suture. *c*, Combined relaxing and coapting suture; one of the best sutures for use where there is marked tension.

Michel metal clips are used for the coaptation of skin. They should not be used for parts under tension and, to prevent scarring, should be removed within seventy-two hours.

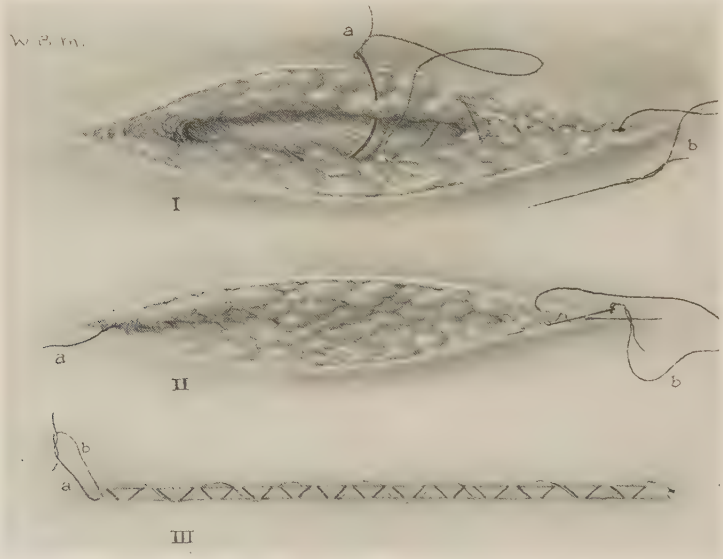


Fig. 435.—Closure of the superficial and deep fascia by a continuous buried and intracuticular suture of fine 00 plain catgut, all knots being buried.

Ligatures are threads or cords used to constrict a part and prevent leakage of blood or other fluid. Therefore ligatures usually cause some degree of tissue necrosis.

Chain Ligature: Used in tying an ovarian or other pedicle in sections. A long thread is carried through the pedicle at one place, and seized by a forceps. The long end of the same thread is then carried through the tissues at one or more other places, and the loops secured. When all are in place, the loops are cut and the individual ligatures crossed with those adjacent and tied, so that finally the whole mass is constricted in sections by a chain of interlocking ligatures.

Double Ligature: The ligation of a vessel at two places, between which the vessel is divided.

Fig. 436.—Michel metal clips.

Fig. 437.—Forceps for the application and removal of Michel clips.

Erichsen's Ligature: A double thread of white and black for the chain ligation of the base of a nevus or angioma.

Fig. 438.—The application of Michel clips for cutaneous closure. Not to be used if there is tension. To avoid scarring, the clips should be removed within three days.

Lateral Ligature: One used to close lateral openings in the wall of a vessel.

Subocclusive Ligature: One so applied to the wall of vessel as to modify, but not interrupt, the blood-current.

Occluding Ligature: One which completely obstructs a vascular or other channel.

Soluble, Absorbable Ligature: Composed of animal membrane (catgut, the prepared fibrous submucous coat of the sheep's intestine) or other substance (magnesium wire) which will ultimately be absorbed by the tissues.

Knots.—*Clove-hitch:* A knot formed of two contiguous loops which are placed around an object, the ends of the cord being toward each other. It is used for making traction on a part, as in the reduction of fractures and dislocations, and for the occlusion of Dakin tubes.

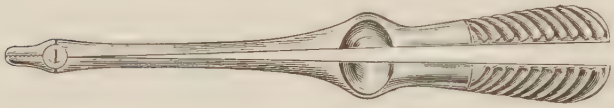


Fig. 439.—Babcock's needle-holder.

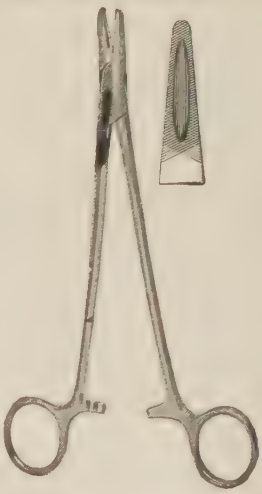


Fig. 440.—Mayo-Hegar needle-holder.

Friction Knot (*Double Knot*): One in which the ends of the cord are twisted twice around each other before being tied. It is useful in tying silkworm-gut sutures. The tension can be readily reduced or increased.

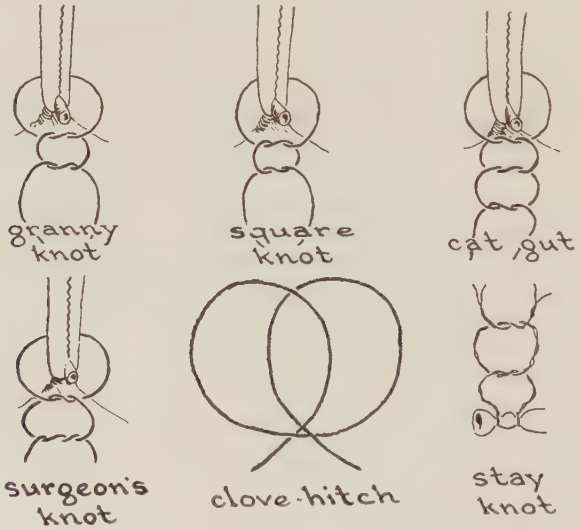


Fig. 441.—Knots employed in surgery.

Granny Knot (*False Knot*): A double knot, in the second loop of which the end of one cord is over, and the other under its fellow, so that the loops do not lie in the same plane and may slip.

Reef Knot (*Square Knot, Sailor's Knot*): A double knot in which the free ends of the second knot lie in the same plane as the ends of the first knot.

Staffordshire Knot (*Tait's Knot*): Formerly often used for tying pedicles. A loop of the ligature, having been passed through the pedicle by a needle, is carried over the pedicle and the two ends of the ligature tied by a reef knot over the loop.

Stay knot is made with two or more ligatures, each being tied with the first half of a reef knot, then all the ends on one side and all the ends on the other side are tied together as if they completed a simple knot.

PLASTIC SURGERY

Plastic surgery consists in the correction or improvement of defects of the body by the removal, movement, or replacement of tissue. Plastic operations are employed for cutaneous and occasionally deep defects. A sharp, clean-cut

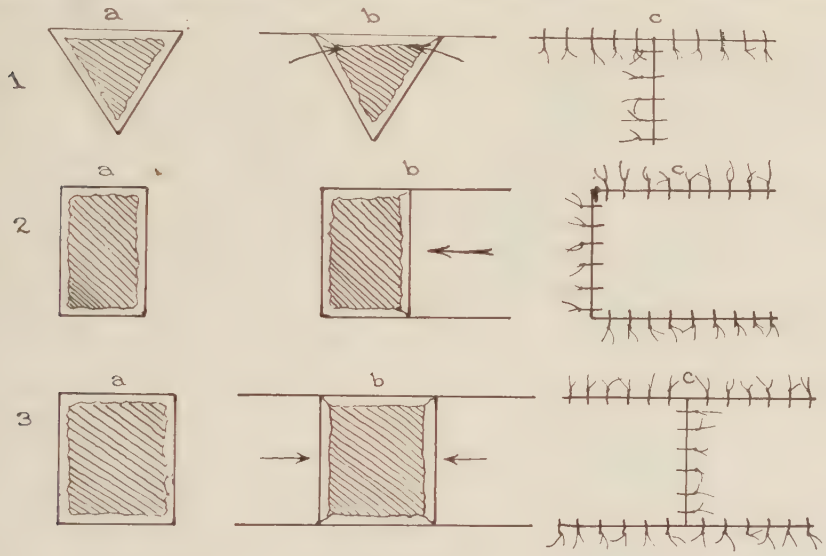


Fig. 442.—Closure of defects in the skin by sliding flaps formed of adjacent tissue: 1, Closure of triangular defect. 2, Closure of rectangular defect by single sliding flap. 3, Closure of rectangular defect by two sliding flaps.

incision, avoidance of crushing or other unnecessary traumatism, accurate hemostasis with fine ligatures without mass constriction of tissue, careful asepsis, and the elimination of irritating or destructive antiseptics are essential for the best results. The success of the operation may be jeopardized by the general condition of the patient—especially by syphilis, diabetes, nephritis, or local conditions interfering with healing, as arterial sclerosis, edema, recent traumatism, infection, operation, or the presence of scar tissue. Tissues that have been burned, radiated by Roentgen rays or radium, or that are the seat of destructive disease, such as lupus or syphilis, have a low vitality and frequently slough when plastic operations are attempted.

Tissues moved without complete detachment are mobilized by undercutting

and by relaxing incisions. The skin or mucous membrane should be moved with the underlying and attached subcutaneous or submucous fat or fascia. The plane of tissue separation preferably should lie between the deep fascia and muscular aponeurosis. To reduce the interference with the nutrition of the mobilized tissue, incision or injury of the blood-vessels in the subcutaneous or submucous fascia or fat should be avoided as far as is possible.

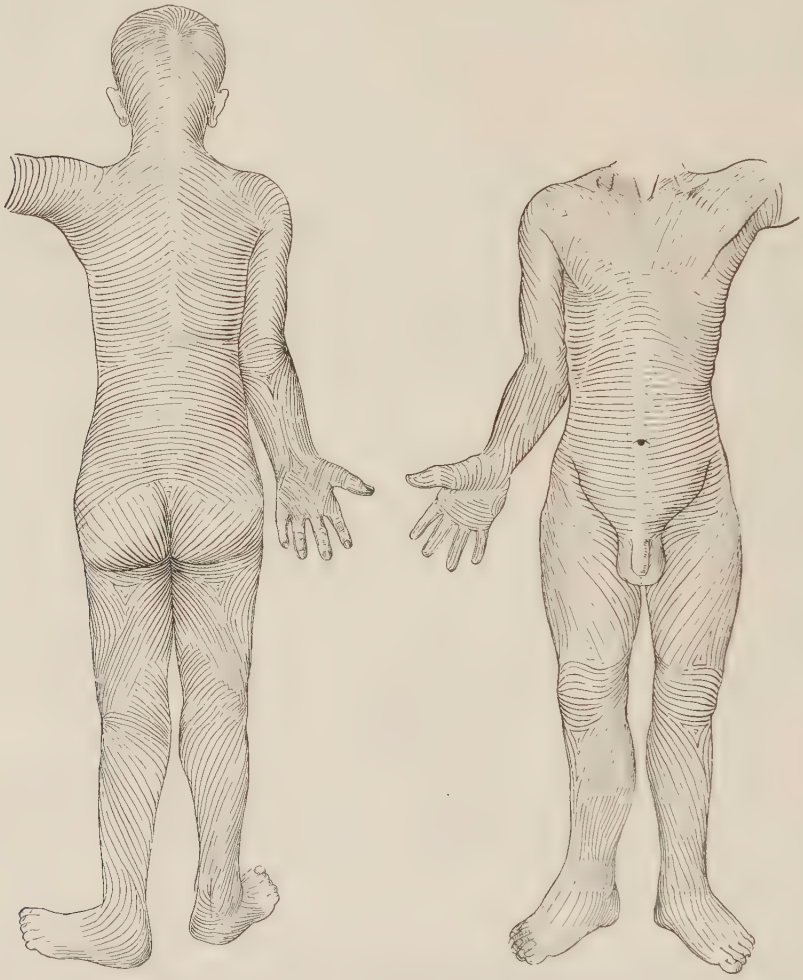


Fig. 443.—Lines of skin cleavage; incisions made along these lines show the least gaping and give the best scars.

Approximation is obtained by: 1. **Stretching** and **sliding** with undercutting. This is the simplest and most generally useful method for approximation. Sliding can often be used instead of skin-grafting and with a better functional and cosmetic result. It is less often complicated by sloughing than operations employing flaps. By it very large defects upon the trunk, neck, and face may be closed. Toward the hands and especially toward the feet, the blood-supply becomes gradually less and a skin tension, easily tolerated upon the

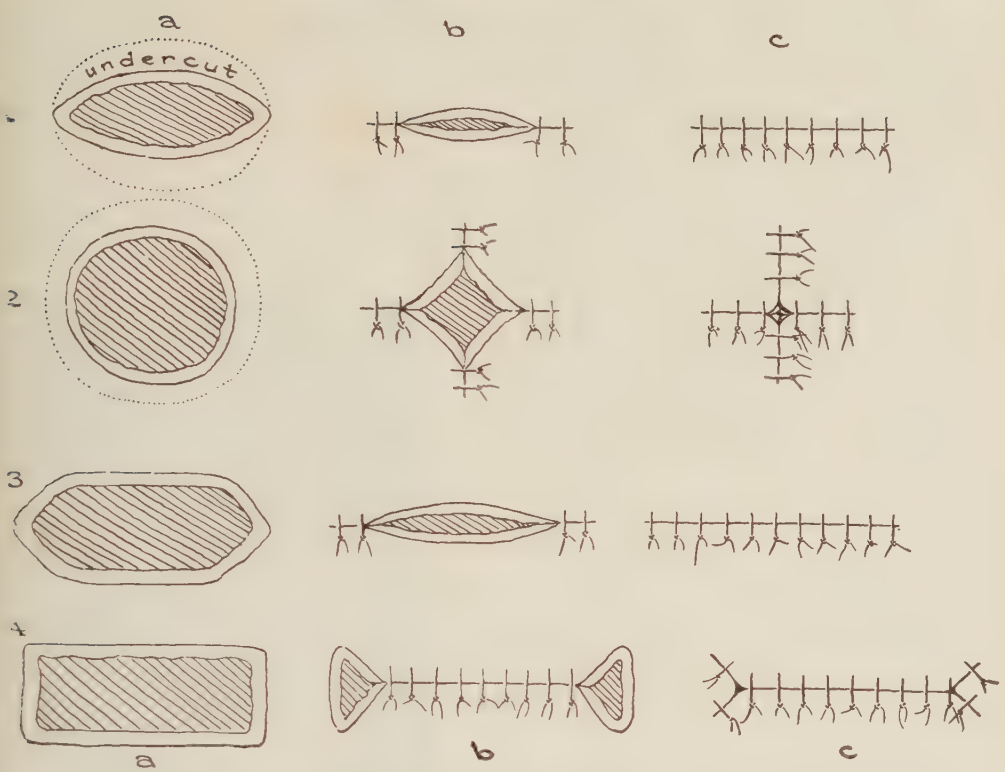


Fig. 444.—Plastic closure of defects in the skin by stretching and sliding: 1, Elliptic defect—the wound margins are liberated, slid together, and united by sutures as shown in *b* and *c*. 2, Closure of circular defect. 3, Closure of oval defect. 4, Closure of rectangular defect.

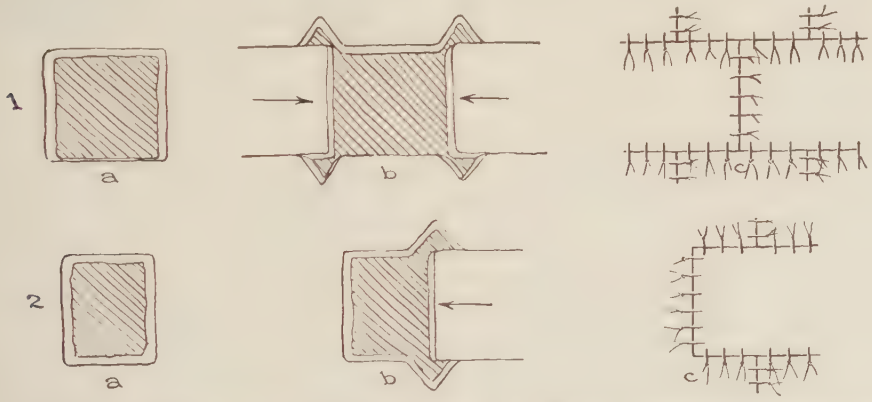


Fig. 445.—Closure of rectangular defects by sliding adjacent flaps of tissue, aided by the excision of triangular segments: 1, Closure of rectangular defect by two sliding flaps, with the removal of four triangular sections. 2, Closure of rectangular defect by a single sliding flap with the removal of two triangular portions of tissue.

trunk or face, causes sloughing. Hence, other methods for overcoming defects are here often required.

2. **Relaxing incisions** enable the surgeon to gain length at the expense of

breadth or *vice versa*. Relaxing incisions may be (a) left open, and permitted to close by granulation as in *uranoplasty*. If closed by suture the opening is (b) closed at right angles to the line of incision, converting a longitudinal incision into a transverse wound, or by (c) converting a V-shaped incision into a Y-shaped wound, or by (d) a Z plasty.

3. **The Use of Flaps:** A *simple flap* consists of skin and subcutaneous tissue only. A *compound flap* includes other structures as bone, cartilage, or muscle. A flap may be made compound after being elevated by embedding bone or cartilage. *Double-faced flaps* or *lined flaps* have an epithelial covering on both sides one side being covered after the flap is raised and before transplantation: (1) By skin-grafting, (2) by folding the flap, or (3) by uniting two flaps, raw surface to raw surface.

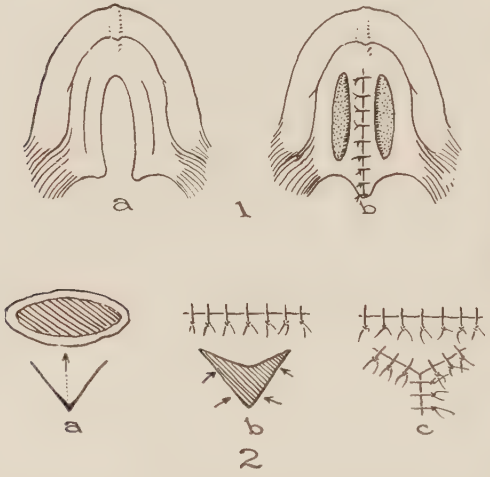


Fig. 446.—Closure of defects by relaxing incisions: 1, Lateral relaxing incisions used in uranoplasty. 2, Closure of elliptic defect by V-shaped incision which is so sutured as to form a Y as shown in *b* and *c*.

Fig. 447.—Double-pedicled flap transplanted from abdomen to dorsum of hand and fingers in two stages. Although the extensor tendons of three fingers have been destroyed, extension is produced by the elasticity of the flap. The patient, a laundress, had the back of her hand crushed and burned in a mangle.

Island flaps are those in which the epithelial surface is completely divided, the pedicle consisting only of subcutaneous tissue or of blood-vessels.

After the transfer and union of a flap, the unused portion may be returned to partially fill a defect. The defect left from the transference of a flap also may be closed by plastic operation or skin-grafting.

A flap is moved by *direct transference*, being sutured at once into its permanent position; or by *indirect transference*, the flap having one or more intermediate points of attachment and sources of nutrition, before reaching its final position. For example: A flap from the abdomen or foot is attached to the hand and, after the new source of blood-supply has been established, carried to the desired place upon the face or neck; or the flap may be "walked" or "waltzed"

(Halsted, 1898) in measuring-worm fashion from one part of the body to its intended destination. Sufficient time should elapse before each movement for the development of an adequate new blood-supply.

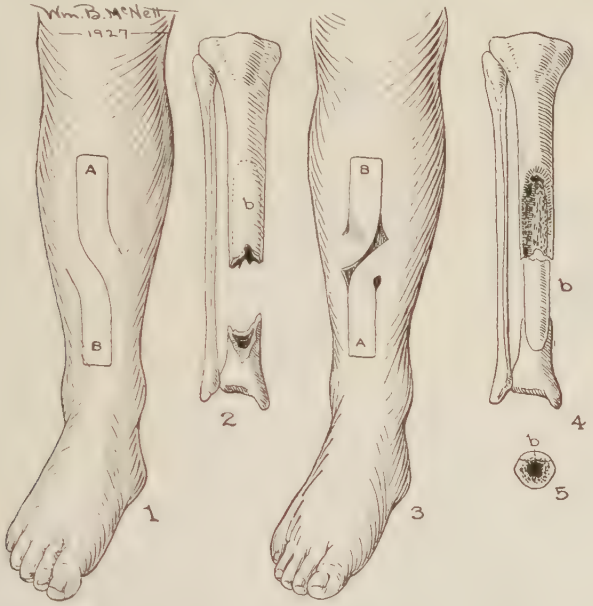


Fig. 448.—Rotation of compound flaps with bone-grafting for defect in the tibia: Flap A is raised with an underlying attached layer of bone *b* from the upper fragment of the tibia, and rotated into the position previously occupied by flap B; thus bridging the bone defect as shown in 4.

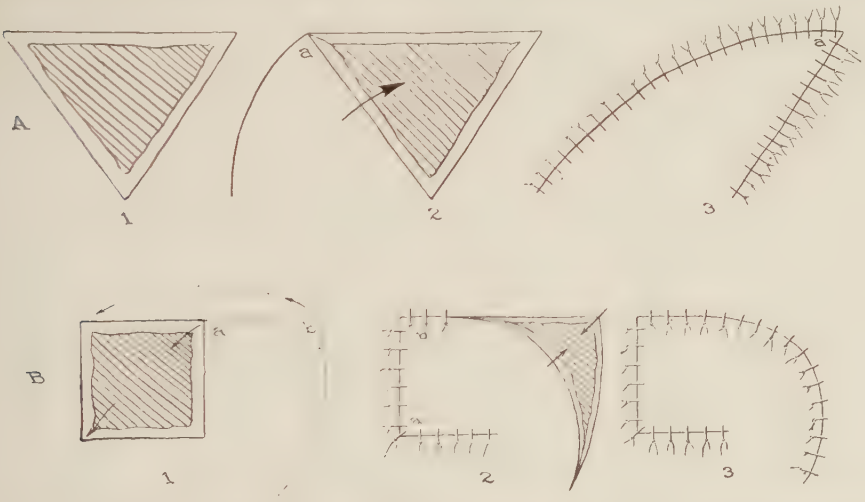


Fig. 449.—Closure of defects by rotating adjacent flaps of tissue: A, Closure of triangular defect: 1, By rotation of flap as shown in 2 and 3. B, Closure of rectangular defect: 1, By rotation of flap as shown in 2 and 3.

Tube grafts (Gillies) are used for convenience of transference: The flap is raised and sutured in the form of a tube, the cutaneous surface being outward.

After it has been carried to the proper location, the tube is reopened and fitted into the defect.

(a) *The Sliding of Flaps (French Method)*: One or more flaps formed of adjacent skin and subcutaneous tissue are slid over the defect to enable a closure.

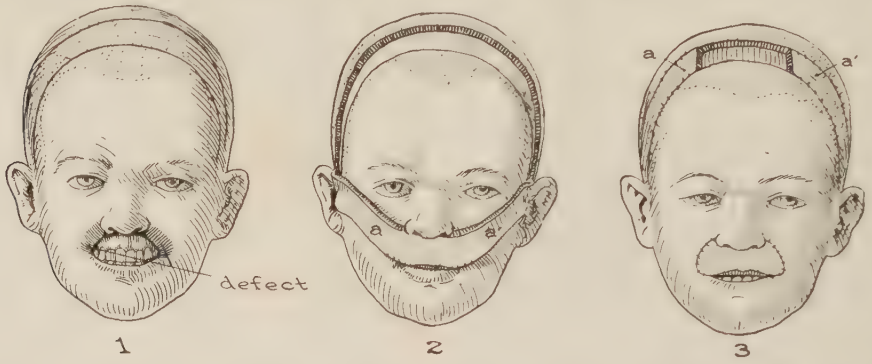


Fig. 450.—1, Double-pedicled flap from the scalp used for the formation of a new upper lip; 2, the flap, previously raised and lined by Thiersch grafts, in place; 3, flap in place, unused portions returned to original position in scalp.

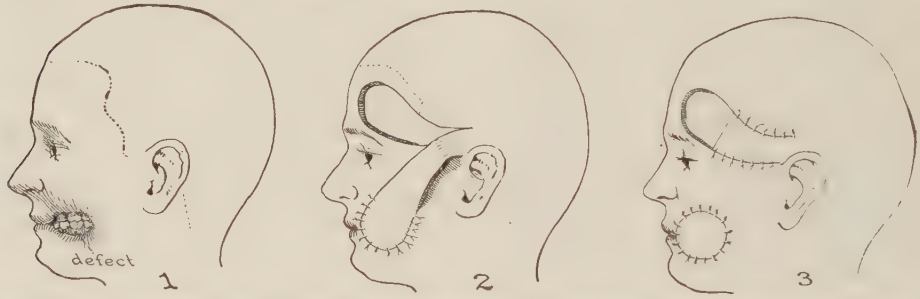


Fig. 451. 1, Closure of defect in the cheek by the use of a pedicle flap; 2, transplanted flap in place; 3, unused portion of flap returned to its original position.

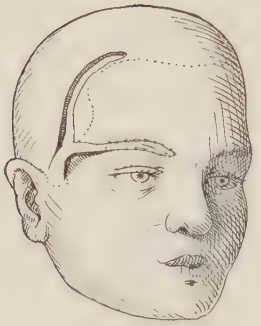


Fig. 452.—Formation of hairy eyebrow by a pedicled flap from the hairy scalp.

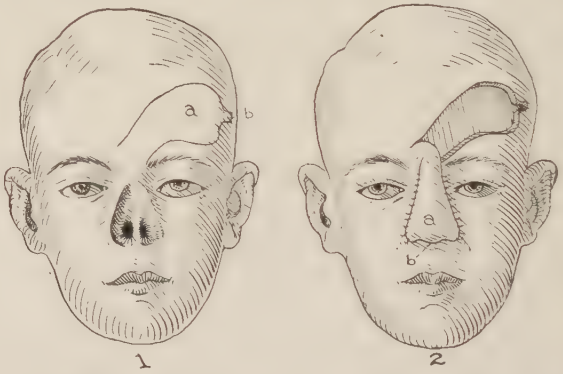


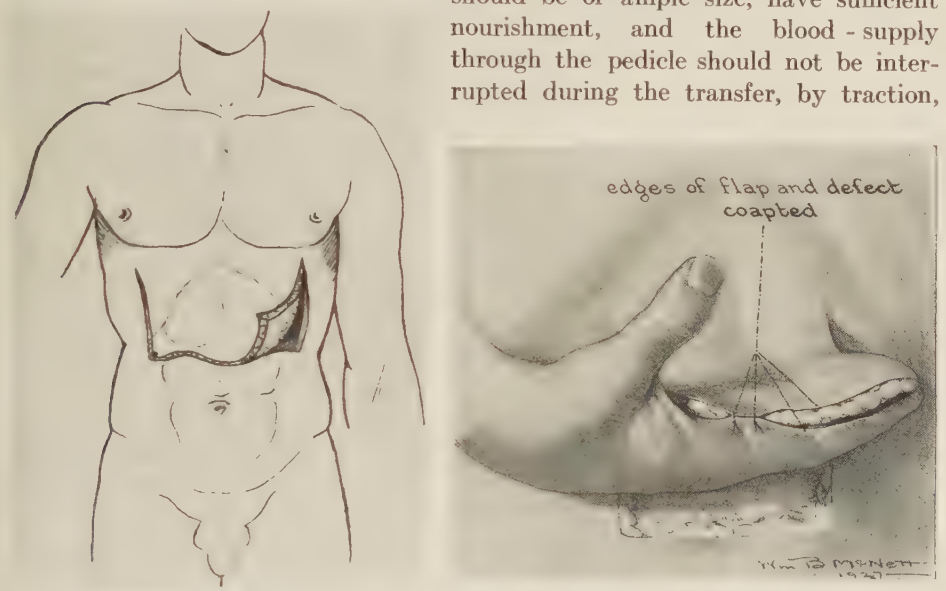
Fig. 453.—Correction of defect by rotation of pedicled flap, rhinoplasty by the Indian method.

In the sliding of flaps the closure may be facilitated by removing V-shaped sections of adjacent tissue to avoid folds and puckers (Fig. 445).

(b) *Rotation of Flap (Indian Method)*: A flap formed of adjacent skin is rotated in a manner to cover the defect.

(c) *Transfer of a Flap with a Vascular Pedicle Only:* The pedicle may be formed of the nutrient artery or the nutrient artery and vein only (Moss, 1898). This method has been used on the face with the temporal artery as a pedicle. The insufficient venous and lymphous drainage may jeopardize the life of the flap. As a rule, transplanted flaps should be at least one-sixth oversize to allow for shrinkage.

(d) *Transfer of a Flap from a Distant Part of the Body (Italian Method, Tagliacotian Method)*: Pedunculated flaps may be transplanted not only from adjacent or distant parts of the body, but also from another person. The flap should be of ample size, have sufficient nourishment, and the blood-supply through the pedicle should not be interrupted during the transfer, by traction,



1 2

Fig. 454.—Transplantation of large single pedicled abdominal flap to the hand. 1, Formation of large abdominal flap; 2, use of abdominal flap to cover volar surface of hand and fingers.

torsion, twisting, or pressure. The pedicle is divided when the flap has sufficient vascular union, usually after ten to fourteen days.

Transplantation of Parts.—Only tissues, the cells of which will withstand separation from their source of blood-supply for a number of hours, are transplantable without a vascular pedicle. Tissues, the cells of which are dead, may, however, be embedded in the body and serve as a scaffolding for the ingrowth of living tissue. Even heterologous and alien tissues may be used. Thus sterile portions of sea-sponge embedded in a wound are invaded by granulation tissue, which may become organized into fibroconnective tissue. Sterile, boiled, alien bone after implantation is eroded and invaded from the surrounded living tissues, and especially when replacing bones formed in membrane may persist for many months. As a rule, however, implanted dead tissues are gradually absorbed and removed. With certain tissues, as the prepared fibrous layer of the intestine

(catgut) absorption occurs very rapidly. If absorption is greatly delayed or difficult, the implanted substance may be encysted, or surrounded by fibroconnective tissue.

Skin-grafting is an operative method to cover defects on cutaneous and mucous surfaces by the transplantation of epithelium. For success the grafted epithelium must be homoplastic or homologous, preferably *autogenous* or derived from other portions of the patient's body. Skin-grafting from other per-

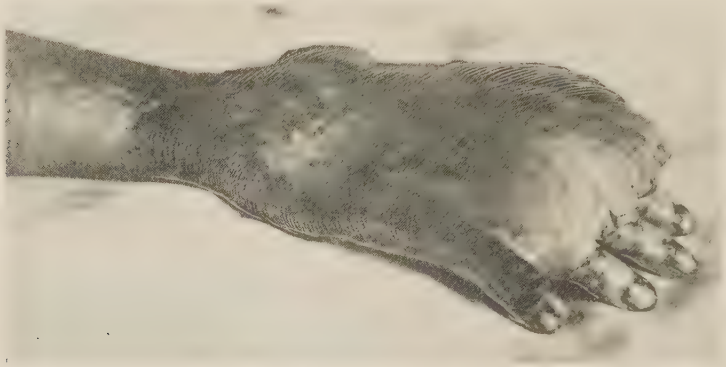


Fig. 455.—Large pedicled flap transferred from anterior abdominal wall to the dorsum of hand and wrist—tenth day. To be contoured by later plastic operations.

sons is not as successful. Heterologous epithelial grafts, or those taken from other species of animals, invariably fail to grow.

Preparation of the Surface to be Grafted.—The wound should be free from necrotic tissue, active sepsis, irritating discharge, or active hemorrhage. Skin-grafts may be placed upon a freshly denuded vascular surface, or a thin, firm, healthy, granulating surface. The skin from which the grafts are to be removed is cleansed with neutral soap and water and ether. On the denuded sur-

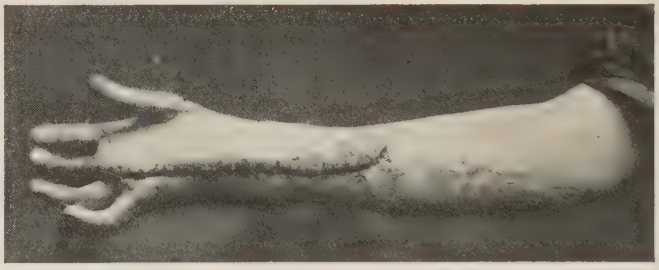


Fig. 456.—Abdominal flap united to forearm and hand.

face only sterile saline solution is used. Antiseptics as iodin, phenol, or sublimate are to be avoided. Flabby and exuberant granulations should be curetted away, and pressure applied until all bleeding has ceased, before grafting is attempted. Obviously the avascular surfaces of fat, aponeurosis, or tendon are not well adapted for grafting. Such tissues serve well, however, when covered by healthy granulations. Epithelial grafts may successfully be used on fresh-

ened vascular or granulating bone. The exposed grafts should be covered by overlapping narrow strips of thin gutta-percha tissue, Lister's green protective, oiled

Fig. 457.—Transference of pedicled flap from the thigh for a defect on the medial side of the foot.

Fig. 458.—Transference of flap from anterolateral thigh to foot. The parts are held by a plaster mold for ten days in the position indicated; the pedicle is then divided.

silk, silver foil, or cello-silk, and this in turn by a thick gauze or sponge compress wet with saline or boric-acid solution. A second sterile covering of impermeable material is applied to prevent evaporation, followed by a layer of cotton and a well-fitted bandage to prevent movement. A slight slipping of the dressing may displace and destroy the grafts.

For the thicker whole-thickness grafts, elastic pressure—as by the use of a sterile moist sea or rubber sponge (Davis) applied over the cello-silk—is of great advantage.

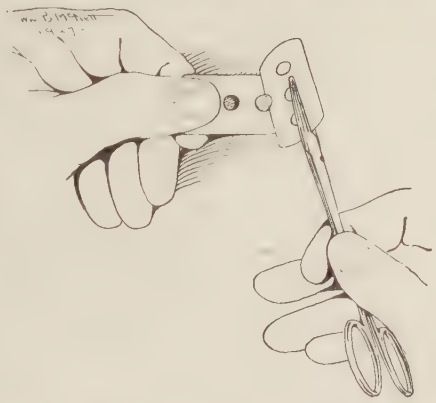


Fig. 459.—Thornton's method of removing pinch grafts with two safety-razor blades.

Methods.—1. *Mangolte's method of skin-grafting* consists in sowing scrapings of epithelial cells from sterilized skin upon the clean bloodless wound surface.

2. *Reverdin's or Pinch Grafts, or Cuticle Grafts (Reverdin-Halsted).*—Minute particles of the entire skin are transplanted, being separated 1 or 2 cm. from each other. The skin is raised by traction on a hair or by elevating the skin on the point of a needle, and the superficial particle of skin removed, preferably with a

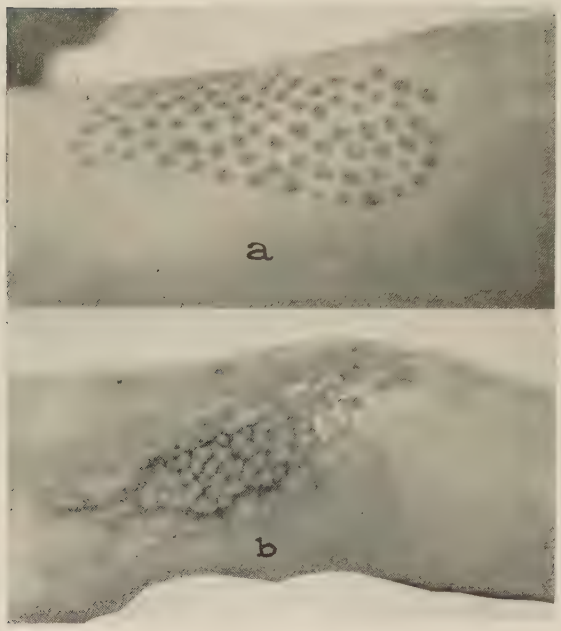


Fig. 460.—Pinch grafts: *a*, Scars on thigh from removal of grafts; *b*, tessellated scar several months after the grafts have healed in place. If the granulating area is not too large, better cosmetic results are obtained by zinc chlorid sterilization and excision of the granulation tissue and mobilization and approximation of the wound edges by a plastic operation.

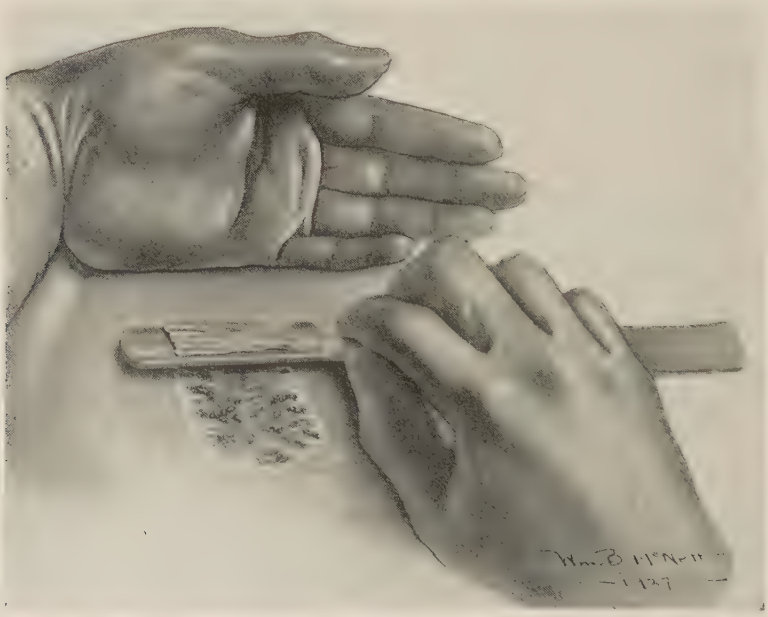


Fig. 461.—Removing Thiersch's grafts: The skin is stretched and flattened by pressure of the side of the hand, and the thinnest possible layer of the epidermis and papillary layer of the skin removed by a sawing motion with a very sharp razor. Most operators prefer a drawing movement of the razor to the pushing movement illustrated.

sharp knife. Under proper conditions each transplanted graft will show a centrifugal proliferation for about $1\frac{1}{2}$ cm. Thornton removes these bits of skin by using two Gillette safety-razor blades. Reverdin grafts produce an unsightly tessellated scar.

3. *Thiersch's grafts* (*epidermal grafts, Ollier-Thiersch grafts*) consist of larger pieces of epidermis with only the outer papillary layer of the dermis. The skin

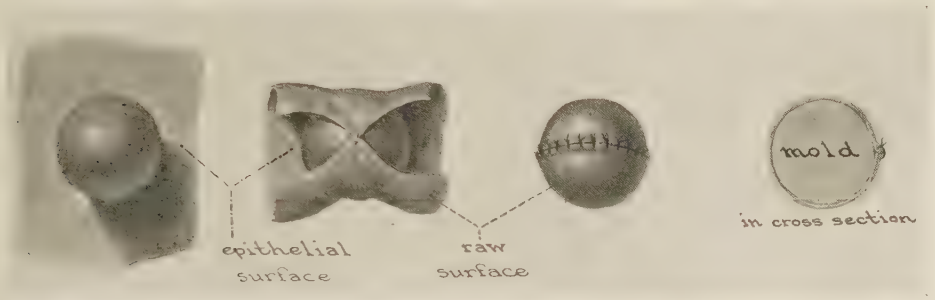


Fig. 462.—The Esser inlay graft: A Thiersch skin-graft is sutured with the epithelial surface in, over a stent made of dental modeling compound.

is stretched and with a very sharp razor, dipped in saline and held nearly parallel with the skin, the thinnest possible cutaneous layer is removed by sawing movements. The edge of the graft is fixed to the granulating or denuded surface by a needle, and the razor slipped from under the graft—the technic resembling that employed in mounting a microscopic section. Denuded surfaces left from removal of the grafts soon heal if thickly dusted with thymol iodid to form a scab; or if covered by a simple ointment dressing.

Fig. 463.—The Esser inlay graft: Obliterated orbital cavity to be lined.

4. *Wolfe's grafts* (*Wolfe-Krause grafts*) consist of the whole thickness of thin hairless skin from which the subcutaneous fat is removed. This form of grafting more frequently fails, as the thicker layer of transplanted skin does not obtain sufficient nourishment. The edges of the graft may be tacked in position by fine silk sutures. During the first three or four days an even light pressure should be used over the graft from a soft marine or rubber sponge.

5. *Esser's inlay grafts* are valuable in grafting upon mucous surfaces. In this way a new lining may be formed in the orbit for the introduction of an ar-

tificial eye; a new mucous lining for the cheek, or a new urethra constructed. Large Thiersch's grafts are used which are sewn, epithelial side in, over a suitable

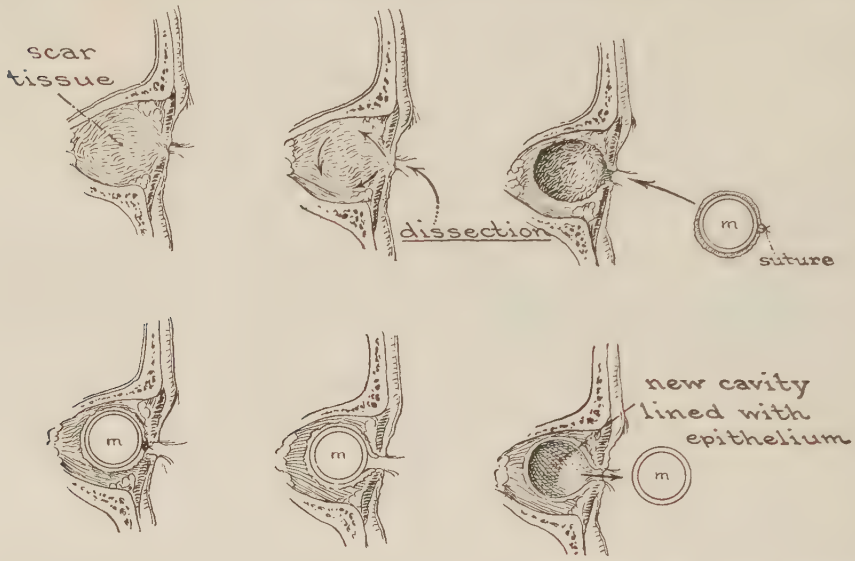


Fig. 464.—Esser's inlay graft, illustrating steps in the preparation of the cavity, the insertion of the epithelial covered stent which is sutured in place, and the final expulsion of the stent, leaving a cavity lined by living epithelium. The same principle is used to enlarge the mucous lining of the cheek, or to form a new urethra.

stent, usually shaped of dental modeling compound after it has been softened in hot water. The stent may be globular, cylindric, or egg-shaped according to the defect to be overcome. An incision is made through the mucous membrane, and a pocket formed of sufficient size to hold the stent. The stent covered by the skin-graft is then buried in the prepared pocket, in such a manner that the seam or suture line of the graft will correspond to the suture line in the mucous membrane when the opening of the pocket is closed. The opening in the mucous membrane is immediately closed by sutures. In about a week or ten days the stent is spontaneously extruded, leaving the pocket lined by epithelium. This method has the merit of protecting the graft from the destructive action of mucous secretions during the period of early healing.

Fig. 465.—New orbital cavity formed by the Esser method.

Transplantation of homologous living connective tissue is entirely feasible. *Transplants of fat* obtained from the subcutaneous tissues or great omentum are implanted under the skin in plastic surgery to improve contours. The intrathoracic, extrapleural implantation of fat has been used to produce collapse of cavities within the

lung, or to obliterate pleural cavities. Transplanted fat usually becomes firmer and more fibrous after transplantation, and the transplant has occasionally later been mistaken for a tumor, and removed. *Transplantations of bone*, tendon, and fascia are often successful, the graft, as a rule, being autogenous. For bone-grafting, bone contiguous to the field of operation, or from the tibia is used. For covering defects in the skull, transplants of pericranium with attached thin scales of bone, raised by a sharp chisel and flattened by a mallet, are excellent. *Transplants of fascia*, usually obtained from the fascia lata, are used to reinforce joints or weak areas on the abdominal wall. Narrow strips of fascia have been used to form sutures of living tissue, especially in the repair of hernia (McArthur). Freshly removed tissues are to be preferred.

Fig. 466.—Receding chin (bird-face) from ankylosis of the jaw.

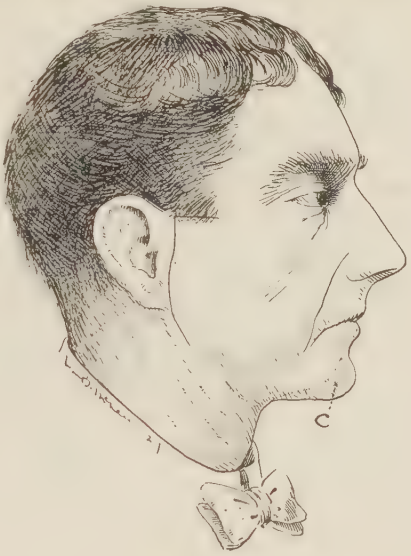


Fig. 467.—Correction of receding chin by the implantation of contoured costal cartilage introduced by an incision from beneath the mandible. By an arthroplasty the movements of the mandible had previously been restored.

Tissues that have been kept in a sterile condition in a refrigerator should be considered as dead tissues. *Transplantation of peripheral nerves*, especially when the longer transplants are used, have rarely been successful. Fibrosis and degeneration soon occur in the lower end of the graft, blocking the down-growth of neuraxis which may have entered the proximal end.

Transplantation of sections of veins and arteries is practicable. A section of a vein usually is implanted to take the place of a section of a contiguous artery. The transplanted section of vein thickens and soon acquires the characteristics of an artery. Newly formed lymphatics have been observed in healing wounds and in transplanted tissue by the fourth day.

Neoplasty, the formation of new parts by plastic methods, has chiefly been used for the nose (*rhinoplasty*), thumb, or finger.

1. *Transplantation of a Toe as a Substitute for an Absent Finger or Thumb* (Nicoladoni, 1892).—(a) The end of the stump of the finger is resected, the tendons liberated. (b) A curved dorsal incision is made over the appropriate joint of the selected toe, the extensor tendons divided, and the toe so dislocated as to be brought in apposition to the stump of the finger or thumb, the plantar attachment carrying the blood-supply being retained. The parts are fixed by plaster or bandages (for ten to eighteen days) until a sufficient union has occurred to the finger, when the volar pedicle of the toe is divided and the flexor tendons and remaining soft tissues united to those of the hand. If possible, the joint capsule is united at the first operation.

2. *Finger Exchange Method.*—This method is similar to that of using a toe; for example, the ring-finger of one hand is substituted for the loss of the thumb of the opposite hand by a two-stage operation (Joyce, 1918).

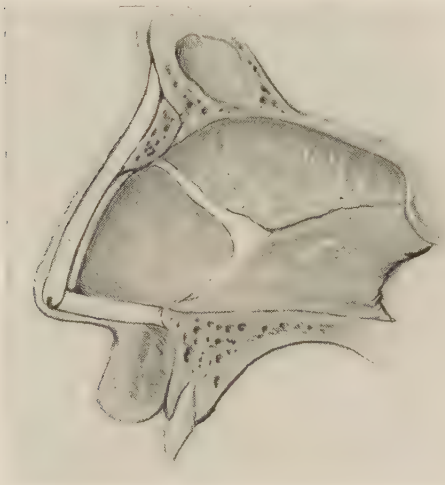


Fig. 468.—Elevation of depressed nose by implantation of contoured costal cartilage above nasal bone, with a prop of costal cartilage embedded in the columella. The operation is performed through a single incision in the columella.

3. *Phalangization Method* (Pieri, 1913).—To form the finger or thumb, the corresponding metacarpal bone is isolated from its fellows and surrounded by skin.

4. *By a Compound Abdominal Flap* (Albee-Schepelmann, 1919).—The soft structures of the new finger or thumb are formed of a pedicled flap from the abdomen. Into this flap a transplant of bone is made, using a section of the fibula, rib, or one of the phalanges or metatarsal bones.

Reimplantation of Completely Separated Parts Without a Vascular Connection.—When a part of a finger, toe, or the nose is completely separated from the body by sharp, clean-cut incision and is promptly reattached, it will at times reunite. With a finger or toe, it is of advantage to lightly suture the subcutaneous tissues, avoiding constriction and tension and leaving the skin ununited to prevent constriction and to facilitate the drainage of lymph. At times an apparently devitalized finger or thumb which remains attached to the hand may be saved by turning back flaps of skin, and embedding the part under the skin of the anterior abdominal wall until a circulation has been reestablished (Babcock, 1907). The experiments upon animals by Abbe (1893), Carrel, and others have shown the feasibility of reuniting, by the aid of an accurate vascular anastomosis, a recently severed arm or leg. It is to be recalled, however, that complete interruption of the blood-supply of the arm or leg for over two hours is often followed by gangrene. The successful union of a separated arm or leg with the human body has as yet not been accomplished.

Transplantation of an entire joint, especially of the knee-joint, is feasible. In a few instances Lexer has successfully used a joint taken from an amputated

leg, or from a body immediately after death. In one of Lexer's patients a psychosis developed as the patient brooded over being the host of a knee from a dead body.

Transplantation of Organs.—With a vascular anastomosis this has been attempted without complete success in human practice. With suitable attachments to the renal artery and vein, Carrel has been able experimentally to transplant the kidney of a cat into the neck of the animal, the transplanted organ continuing to excrete urine for a number of weeks.

Transplantation of Organs Without Vascular Anastomosis: This apparently has been most successful in the case of the ovary. A section of the ovary or an entire ovary, taken from another woman, is immediately transplanted into the broad ligament or uterine wall of a patient from whom the ovaries have previously been removed. The operation has been used to relieve sterility or the violent symptoms due to the artificial menopause. Some mitigation of the symptoms of the climacteric, and in a few instances, as in the cases reported by Morris, Bainbridge and others, pregnancy has followed. Such evidences of a successful transplantation must be accepted with caution, as it is often difficult to prove that all ovarian tissue was removed at the first operation, and in a number of instances pregnancy has followed what was considered to have been a complete bilateral oöphorectomy. As a rule, the internal secretions of the transplanted organ are soon extracted by the host, and the organ undergoes degeneration and more or less complete absorption. Many attempts have been made to transplant the human testes. Stanley has repeatedly used organs taken from recently executed criminals. A permanent successful transplantation apparently has not been accomplished. Simpler and more satisfactory than the implantation of the entire testes are the results obtained by implanting thin slices of the testicle, or by injecting the finely minced fresh organ through a hollow needle into the vascular tissues of the body. Such injected or implanted material supplies the body for a number of weeks or months with the internal testicular secretion. Permanent effects are not to be expected. Reviving and revising the old theories of Brown-Séquard, the use of the testicles of monkeys for the restoration of youth and prolongation of life has been exploited by Voronof. Thyroid gland has been transplanted to relieve myxedema and cretinism. As with the testicle, the thyroid after transplantation usually soon degenerates and is absorbed or expelled. Experimentally the transplantation is more successful if made into very vascular tissues, especially the spleen or bone-marrow. Practically, the transplantation should be limited to the embedding of thin slices of thyroid substance, or the injection of recently removed minced or scraped thyroid into muscle or other vascular tissue. The feeding of desiccated thyroid is so effective that few attempts are now made to transplant the thyroid gland. In every thyroidectomy Lahey urges that the removed gland be immediately examined for any attached parathyroid tissue which, if found, should immediately be implanted in the sternocleidomastoid muscle of the patient to prevent secondary tetany.

CHAPTER XXX

LIGATIONS

Ligation of Arteries.—In applying a ligature to an artery in continuity, the sheath of the vessel should be opened, the ligature passed inside the sheath from the side of the most important structure, and tied tightly enough to coarct the lumen without rupturing the inner coats of the vessel. Partially oc-

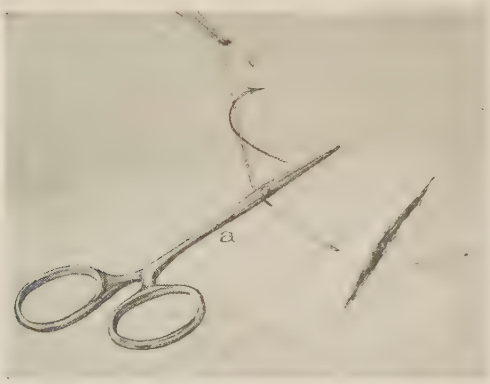


Fig. 469.—Grant's method of tying a knot with forceps (*a*).

cluding and crushing ligatures, applied to large vessels, are dangerous. The ligature should be tied to occlude, but not to crush the artery. A partially occluding ligature, central to a totally occluding one, should not be used.

Fig. 470.—Grant's method of tying a knot with forceps.

Fig. 471.—Grant's method of tying a knot with forceps: First hitch completed.

Fig. 472.—Grant's method of tying a knot with forceps.

Fig. 473.—Grant's method of tying a knot with forceps: Completion of a square or reef knot.

Proximal ligation of an artery for arteriovenous fistula, or varicose aneurysm, is contraindicated from the danger of distal gangrene.

If the artery is a very large one, a *stay knot* may be used for greater security. Two ligatures are applied close together, the first turn of the knot tied in each, and then the two pairs of ends tied together. If the main vein is also ligated the local blood-pressure will rise, aiding the opening of anastomotic blood-channels and reducing the danger of gangrene. Tight ligation with rupture of the inner and middle coats is followed by increased liability of secondary hemorrhage, particularly if the vessel is diseased or the ligature near a large branch. Double ligation, with division of the artery between the ligatures, gives much greater security against hemorrhage than ligation in continuity. After ligation, a clot forms between the ligature and the nearest branches above and below, the clot on the distal side being smaller and slower in formation than that on the proximal. If the ligature is not absorbed too rapidly, the occluded vessel is gradually converted into a fibrous cord. After ligation of a large artery, the blood-pressure rises, increased work is thrown on the heart, the parts below the ligature become cold and pulseless, the anastomotic channels dilate, and pulsation below the ligature is gradually resumed, with enlargement and hypertrophy of anastomotic channels and a temporary hyperemia. Ligation of the main artery permanently reduces the circumference of the limb 1 to 3 cm., with a weakening of the distal pulse, and reduction of the distal blood-pressure from 10 to 20 mm. of Hg. The ligation may be followed by Volkmann's contracture, muscular degeneration, and necrosis or peripheral gangrene. If the collateral circulation is insufficient, gangrene of the dry variety follows, involving the toes or fingers or extending up to the point of ligature, usually between the third and tenth day. It is to be treated, if of limited extent, by waiting until the line of demarcation forms. With very extensive gangrene, early amputation may be necessary to save life. Drainage should not be used after operations upon blood-vessels.

Blood-pressure Sustained by Blood-vessel Wall.—The systolic blood-pressure is only partially sustained by the wall of the blood-vessel, the wall pressure being inversely as the rapidity of the current, and directly as the caliber of the vessel. With high velocities, the pressure may be insufficient to distend the vessel, or the wall pressure may even be negative. With slowing and arrest of the current, the full systolic and diastolic pressure is sustained by the wall of the vessel. Where the vessel is dilated, the current is slowed and the wall pressure increased. Where the vessel is narrowed, there the velocity is increased and the wall pressure reduced. From a partially occluding ligature or band, the pressure on the artery distal to the occlusion should be the same as the pressure on the artery (provided the caliber is the same), proximal to the occlusion, apart from such modifications as are due to gravity and other local factors. If the current is slowed distal to the constriction, the pressure may be increased, based upon well-known hydrodynamic laws. This explains the occasional dilatation of an artery, or the secondary rupture of an aneurysm distal to an arterial ligation or occlusion.

Ligation is made at the *point of necessity* or at the *point of election*. The point of necessity is in the wound or at the point of bleeding; the point of elec-

tion is the preferred point of ligation in continuity, of the main artery supplying the part. As there is less interference with the circulation of the part, ligation at the point of necessity is preferred, provided local conditions (such as infections, neoplastic tissue, or other unfavorable factors) do not prevent.

Indications.—(1) *Hemorrhage*, particularly secondary hemorrhage from necrosis of tissue due to infection. (2) *Tissue destruction* by cautery, electric current, *x*-rays, or radium. (3) *Aneurysm*, ligation being used to favor clotting and obliteration of the sac. (4) *Malignant tumors*, ligation being used to starve

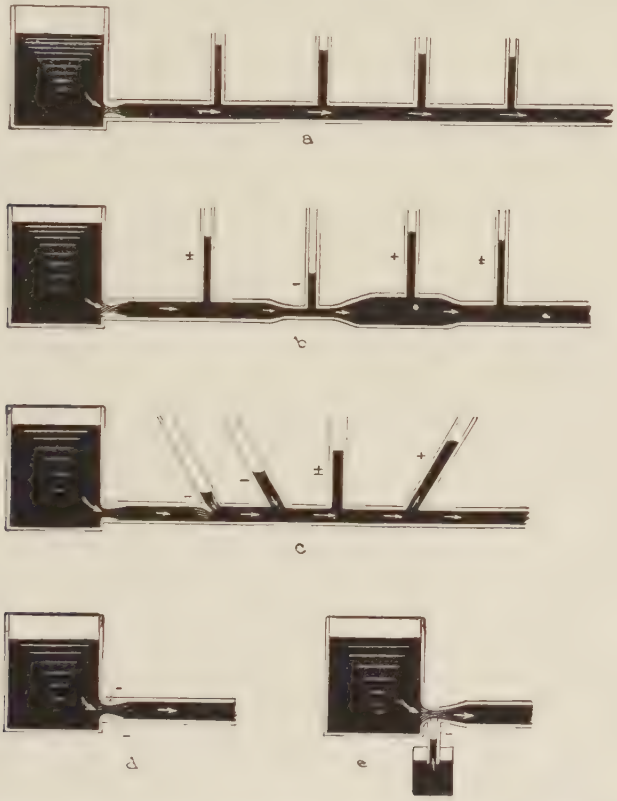


Fig. 474.—Wall pressures sustained by tubes containing moving liquids: *a*, Equal pressures sustained by walls of tube of uniform caliber. *b*, Increase in wall pressure in tube containing moving liquid where the caliber is increased, decrease in wall pressure where the caliber is reduced. *c*, Influence of angulation upon the pressure in branch tubes. *d*, Negative pressure in tube just beyond an orifice. *e*, Improved flow with aspirating or Venturi tube effect produced by narrowing a tube just beyond an orifice.

the tumor, check the rate of growth, and render the malignant tissue more susceptible to destructive agents, as Roentgen rays.

Innominate Artery.—Anatomy.—The innominate artery is 4 to 5 cm. long, and begins at the arch of the aorta opposite the fourth dorsal vertebra, or the upper border of the second right costal cartilage, passing upward, forward, and to the right of the upper border of the right sternoclavicular articulation, where it divides into the common carotid and the subclavian artery.

Relations.—Anteriorly are situated: The manubrium sterni (the origin of the sternohyoideus and sternothyroideus), the sternoclavicular joint, the remains of the thymus, the left innominate vein, the right inferior thyroid vein, and at times the superior cardiac branches of the right vagus. *Posteriorly* lies the trachea and pleura; *to the right:* The right innominate vein, superior vena cava, right phrenic nerve and pleura; and *to the left:* The left common carotid, thymus, the left inferior thyroid veins, and occasionally the small branches, the thyroidea ima, thymic, and bronchial arteries.

Line.—From center of manubrium to the center of the right sternoclavicular joint.

Indications.—*Aneurysm* of the right carotid, subclavian, or innominate arteries. The ligation for aneurysm is unsatisfactory and rarely indicated.

Operation.—Sand-bag support, with head tilted back and to the left. The incision of V or L shape extends $7\frac{1}{2}$ cm. along the lower medial border of the sternocleidomastoideus muscle, and $7\frac{1}{2}$ cm. along the upper border of the clavicle. The skin, fascia, platysma, and deep fascia are opened; the anterior jugular is divided between ligatures; the sternomastoid is retracted laterally; the sternohyoideus and sternothyroideus retracted medially, or divided; the inferior thyroid veins retracted, and the deep cervical fascia over the carotid sheath incised. The right common carotid is traced down to the innominate artery, avoiding the recurrent nerve behind the common carotid. The left and right innominate veins are retracted, the internal jugular vein and the vagus are avoided. The needle is passed from below upward and inward, avoiding the innominate vein anteriorly and the pleura and right pneumogastric nerve, posteriorly and to the right.

Danger.—*Secondary hemorrhage.* The ligatures should be applied high enough to allow for sufficient clot formation, and associated ligation of the common carotid and vertebral arteries may be desirable. Resection or splitting of the manubrium is at times necessary to obtain sufficient room. Care should be taken to avoid the right pleural sac, the trachea, and cardiac nerves.

Collateral circulation is very free and includes: The communication of the first aortic intercostal with the costocervical of the subclavian; the upper aortic intercostals with thoracic branches of axillary and intercostals of internal mammary; the phrenic with the musculophrenic of internal mammary; the inferior epigastric from the external iliac with superior epigastric of the internal mammary; the anastomosis between the two external carotids in the midline of face and neck; of the vertebrals and internal carotids through the circulus arteriosus (circle of Willis), and the transverse cervical with the occipital artery.

Prognosis.—Ligation of the innominate artery gives a mortality of 66 per cent., and often fails to relieve aneurysm. Patients, at first apparently improved, later relapse and die from rupture of the sac. For subclavian aneurysm, Thompson found 41 per cent. of 17 cases recovered following ligation of the innominate alone, 66 per cent. of 12 cases recovered following ligation of both the innominate and carotid arteries.

Right Common Carotid Artery.—Nine cm. long. Passes from the bifurcation of the innominate behind the right sternoclavicular articulation, upward, laterally, and slightly backward to the upper border of the thyroid

cartilage opposite the third or fourth cervical vertebra, where it divides into the internal and external carotid. It lies in a common sheath, the deep jugular vein being lateral and slightly anterior, the vagus between and posterior. It is divided by the omohyoideus muscle opposite the lower border of cricoid cartilage into *lower deep*, and *upper, more superficial portion*. The left common carotid is 11 cm. long, and passes from the middle of the transverse arch to the aorta, upward and laterally to the left sternoclavicular articulation, being overlapped by the left lung and pleura. Above this point the course is the same as that of the right carotid. The common carotids have only terminal branches.

Line.—With head to the opposite side and turned slightly upward, the line runs from the sternoclavicular articulation to a point midway between the angle of the jaw and the tip of the mastoid.

Indications.—Ligation is used for *wounds of the carotid* or its branches, distal and proximal *aneurysm*, *distal angioma; inoperable tumors* of the face, neck, and skull; *hemorrhage* from distal branches, *hydrocephalus* and *epilepsy*. Temporary occlusion of the common carotid is used at times to facilitate extensive operations upon the neck and face.

Sites.—The point of election is above the omohyoideus, in the *triangle of election*. Ligation below the omohyoideus, in the *triangle of necessity*, is more difficult and dangerous on account of the relations and depth of the artery.

Operation.—A 5- to 8-cm. transverse or oblique incision, centering over the cricoid, is made. The skin, fascia, and platysma are divided, and also the deep fascia along the anterior border of the sternocleidomastoideus. The sternocleidomastoideus is retracted laterally, the omohyoideus downward and medially, and the descendens hypoglossi nerve inward. The carotid sheath is opened, the artery ligated opposite the carotid tubercle (*Chassaignac's tubercle*), the transverse process of the sixth cervical vertebra. The needle is passed from without inward, avoiding the internal jugular vein and the vagus.

Low Operation (Below the Omohyoideus).—A transverse or oblique incision is made, centering over the anterior border of sternocleidomastoideus just below the cricoid. The skin, superficial and deep fascia are divided, the sternocleidomastoideus retracted laterally, sternohyoideus and thyroideus divided or retracted medially, the descendens hypoglossi nerve displaced on the sheath, the sheath opened and the needle passed from without inward, avoiding the jugular vein and vagus.

Danger.—Ligation of the common carotid is followed in 26 per cent. of the patients by stupor, fall in temperature, diplopia, blindness, convulsions, coma, aphasia, cardiac and respiratory irregularities, paresis, contralateral monoplegia, chiefly of the upper extremities; or hemiplegia and incontinence of the sphincters, which may be followed by secondary improvement or be permanent, and in 50 per cent. of the cases, is fatal. The incidence increases with age (Halsted).

Collateral Circulation.—The inferior with the superior thyroid artery, the profunda cervicalis with the ramus descendens of the occipital, anastomoses between the right and left external and internal carotids and vertebrals both within (circulus arterious) and without the skull.

External Carotid Artery.—The smaller division (about $7\frac{1}{2}$ cm. long) passes from upper border of the thyroid cartilage upward, forward, and then

backward between the neck of the condyle of the mandible and the external meatus, where it divides in the parotid gland into the internal maxillary and superficial temporal arteries. It lies at first anterior and medial to the internal carotid, and then superficial to it. The descendens hypoglossi nerve is usually on the anterolateral side of the sheath of common carotid.

Relations.—*Anteriorly:* Skin, superficial fascia, platysma, deep fascia, anterior margin of Sternocleidomastoideus, hypoglossal nerve, lingual, ranine, common facial and superior thyroid veins, posterior belly of digastricus, stylohyoideus, temporomaxillary vein, superior cervical lymph-glands, branches of facial nerve, parotid gland. *Posteriorly:* Internal carotid artery, styloglossus, stylopharyngeus, glossopharyngeal nerve, pharyngeal branch of the vagus, stylohyoid ligament, part of parotid gland, superior laryngeal nerve. *Laterally:*

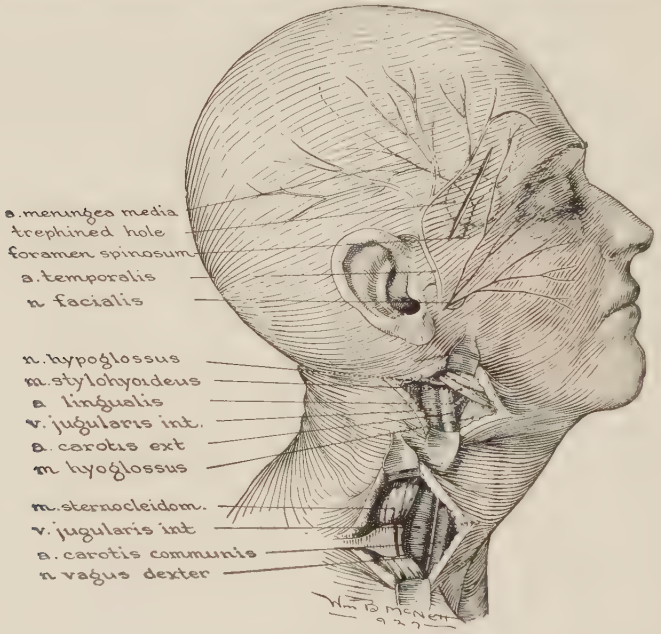


Fig. 475.—Ligation of the anterior branch of the middle meningeal artery, the external carotid, and the common carotid arteries.

Internal carotid artery. *Medially:* Hyoid bone, wall of pharynx, superior laryngeal nerve, ramus of mandible, stylomaxillary ligament, submaxillary gland, parotid gland.

Branches.—From below: The ascending pharyngeal, superior thyroid, lingual, external maxillary (facial), occipital, posterior auricular, superficial temporal, and internal maxillary.

Line.—Upper part of the line of common carotid artery. The *muscular guide* is the sternomastoid.

Indications.—In wounds and aneuryms of the artery and its branches, hemorrhage from the branches, as a palliative treatment for malignant growths, and as a preliminary to operations in the field supplied by the branches, ligation may be indicated.

Operation.—A transverse incision is made 2 cm. below the angle of jaw, centering over the anterior border of sternocleidomastoideus. The skin and platysma are divided by an incision 5 to 7 cm. long; the deep fascia opened, exposing the anterior edge of the sternomastoid, which is retracted laterally. The digastric muscle is located with the hypoglossal nerve below, and these are retracted upward, exposing the artery which is preferably ligated between the superior thyroid and lingual branches opposite the great cornu of the hyoid bone. The needle is passed from without inward.

Collateral circulation, after ligation of the external carotid artery, below the digastric, is the same as that after ligation of the common carotid above the omohyoid, namely: The inferior thyroid with the superior thyroid, the profunda cervicalis from the costocervical with the occipital, the transverse cervical with the occipital, branches of the two vertebrals and branches of the two external carotids, through the circulus arteriosus.

The *external carotid* is distinguished from the internal by its branches, and by its more lateral position.

Internal Carotid.—The artery runs from the bifurcation of the common carotid to the carotid canal in the petrous bone, lying deeper than, and a little posterior to, the external carotid, against the lateral wall of the pharynx.

Branches.—The internal carotid gives off: (1) No branches in its *cervical portion;* (2) in the *petrous portion*, the caroticotympanic artery of the pterygoid (vidian) canal; (3) from the *cavernous portion*, the cavernous, hypophyseal, semilunar, anterior meningeal, and the ophthalmic arteries; (4) from the *cerebral portion*, the anterior cerebral, middle cerebral, posterior communicating, and the choroidal arteries.

Muscular Guide.—Anterior border of sternomastoid.

Incision.—The same as for the external carotid, the hypoglossal nerve and digastric muscle being the deep guides, and the external carotid being first demonstrated. The needle is passed from the lateral side, avoiding the jugular vein, the vagus, and the sympathetic cord. The artery is exposed opposite the tip of the great cornu of the hyoid.

Collateral circulation is through the *circle of Willis.*

Superior thyroid artery arises from the external carotid close to its origin, and just below the level of the great cornu of the hyoid bone. It passes upward and inward and then downward and forward to the upper pole of the thyroid gland. It lies adjacent to the superior thyroid veins and the external branch of the superior laryngeal nerve.

Incision (Crile's Method).—(1) *Anesthesia* by local infiltration with 1 per cent. procain. (2) *Incision* transverse, 2 to 3 cm. long, beginning 3 cm. from the midline on the level of the upper part of the thyroid cartilage. (3) Using narrow retractors, the *fascia is divided* at right angles to the skin incision, a sharp-pointed hemostatic forceps inserted, the muscle bluntly separated to the pole of the thyroid gland. The muscles are retracted laterally and the thyroid grasped, exposing the vessels of the upper pole, around which (by a small, round, curved needle threaded with fine silk or linen) a ligature is passed, making a double loop in the pole of the gland. The deep layers are permitted to fall together, and the skin approximated by two or three Michel clips.

Indication.—Stage operation for toxic goiter in preparation for thyroidectomy.

Inferior thyroid artery is a branch of the thyrocervical trunk of the subclavian artery. A transverse or oblique *incision* is made (as for the common carotid artery), the common carotid artery exposed in its sheath, retracted outward, the omohyoideus upward, the thyroid gland and trachea inward, exposing the inferior thyroid artery opposite the carotid tubercle, as it runs behind the common carotid artery at the level of the omohyoid tendon. The recurrent nerve, which runs close to thyroid gland, usually behind, but occasionally in front of the artery, is avoided. The carotid tubercle is the *deep guide*. The needle is passed between the artery and the vein.

External Maxillary (Facial) Artery.—**Incision** (2½ to 3 cm. long) along the center of the lower border of the mandible, dividing the skin, superficial fascia, and platysma. The vein lying laterally and behind is retracted, and the needle passed from behind forward, the artery being ligated as it crosses the lower border of the jaw just in front of the masseter. The mandibular branch of the facial nerve lying above the margin of the jaw under the platysma and triangularis should be avoided. The anterior facial vein lies lateral to the artery. The facial artery may also be ligated at its origin, using the operative incision for ligation of the external carotid.

Lingual artery (*gustatory*) may be ligated at its origin through the incision used for the ligation of the external carotid. In its second part beneath the hyoglossus and in the submaxillary triangle; it is ligated by a horizontal 2½ cm. incision carried forward from the cornu of the hyoid bone. The skin, superficial fascia, platysma, and deep fascia are divided; the submaxillary gland retracted and fibers of hyoglossal muscles separated midway between the hypoglossal nerve and hyoid bone, exposing the vessel. The needle is passed from above downward.

Vertebral artery is rarely ligated. It arises from the upper and posterior part of the first portion of the subclavian, running upward into the space between the inner border of scalenus anterior and the outer border of the longus colli, as far as the foramen in the transverse process of the sixth cervical vertebra, which it enters. At its origin it is crossed by the internal jugular and vertebral veins, inferior thyroid artery, and on the left side by the thoracic duct. The **deep guide** is the carotid tubercle. The second part of the artery ascends through the foramina in the transverse processes of the upper six cervical vertebræ to enter the skull through the foramen magnum.

Incision is transverse, 4 or 5 cm. long, centering over the carotid tubercle, and dividing the skin, and platysma. The sternocleidomastoideus is drawn laterally, omohyoideus upward, the sternohyoideus medially; the common carotid, internal jugular, and vagus are drawn laterally in their sheath; the recurrent nerve avoided, and the prevertebral fascia incised from the level of the carotid tubercle to the arch of the inferior thyroid artery. The vertebral artery is located under the lateral edge of the longus colli, the scalenus anterior (on which lies the phrenic nerve) being lateral. The ligature may be passed in either direction, care being taken to avoid the fibers of the sympathetic which surround the artery.

Temporal Artery.—**Incision:** A 2½-cm. transverse incision is made from

the tragus forward over the zygomatic arch. The needle is passed from the side of the vein forward.

Occipital artery may be tied at its origin through the incision used for the external carotid.

Incision is transverse, 2½ cm. long, placed just below and parallel to the mastoid process; the skin, fascia, insertion of sternomastoid, and aponeurosis of splenius muscle are divided. The digastric groove (*deep guide*) is felt, and the digastric muscle retracted. The artery lying between the mastoid process and the transverse process of the atlas is exposed. The needle is passed from within outward.

Subclavian Artery.—*On the right side* is 7½ cm. long, and arises from the innominate; on the *left side* it is 10 cm. long, and arises from the arch of the aorta. It arches across the root of the neck, over the dome of lung and pleura, to the outer border of the first rib, where it becomes the axillary artery. The portion medial to the inner border of the scalenus anterior being the first part; that behind the muscle, the second; and that lateral, the third part. The subclavian vein lies below and anterior, the scalenus anterior intervening. The posterior border of the sternocleidomastoideus corresponds with the lateral border of scalenus anterior.

Line is curved, with convexity upward, running at the base of posterior triangle from the sternoclavicular articulation to 2 cm. above the superior border of the clavicle, to the middle of the inferior border of the clavicle.

Ligation of the Third Portion.—Ligation of the *first* or *second portion* is rarely used. The *third portion*—where the artery lies in the subclavian triangle, with the clavicle below, the inferior belly of the omohyoideus laterally, and the posterior border of the sternocleidomastoideus mesially—is usually selected.

The **line** of the third portion is from posterior border of sternomastoid to anterior border of trapezius, 2 cm. above and parallel to the clavicle.

Muscular Guide.—The lateral border of the scalenus anterior, approximately the outer border of the sternocleidomastoideus.

Bony Guide.—The artery lies directly behind the tubercle of first rib, into which the scalenus anterior is inserted.

Operation.—The thorax is raised on a sand-bag, the neck extended, the head turned to opposite side, the arm pulled down with the forearm under the back. Drawing down the skin, to protect the external jugular vein, the incision is made over the clavicle from the outer margin of the sternocleidomastoid to the inner margin of trapezius. As the skin returns to position, the wound lies 2 cm. above the clavicle. The skin, superficial fascia, platysma, and deep fascia are divided, the external jugular vein retracted medially or divided between ligatures, the inferior belly of the omohyoideus retracted upward, the scalenus anterior and the tubercle of first rib identified. The transverse, cervical, and transverse scapular arteries, and the brachial plexus (lying above and to the lateral side) and the lower cord, passing behind, are to be avoided. The needle is passed from above downward, close to the artery, avoiding the posterior cord and pleura.

Incision for first portion is V or L shaped, extending 7½ cm. upward along the anterior border of the sternocleidomastoideus from the sternum, and 7½ cm.

along the upper border of the clavicle; dividing the skin, superficial fascia, platysma, deep fascia, and the sternal and clavicular ends of the sternomastoid muscle. The cellular tissue and small vessels are retracted, the sternohyoideus and sternothyroideus are divided, the inferior thyroid veins and fibrous lamina retracted; the common carotid artery exposed and traced to the innominate (or arch of aorta on left side). The vagus, phrenic nerve, and recurrent laryngeal nerve, the innominate vein, inferior thyroid vein (right side), and the internal jugular vein are retracted. The needle is passed from below upward and medially.

Axillary artery connects the subclavian with the brachial, extending from the lower border of the first rib to the lower border of the tendon of teres major. The *first part*, $2\frac{1}{2}$ cm. long, extends from lower border of first rib to upper border of pectoralis minor. The *second part*, 3 cm. long, lies behind the pectoralis minor and (on account of its depth and the surrounding nerve-trunks) is rarely ligated. The *third part*, $7\frac{1}{2}$ cm. long, extends from lower border of pectoralis minor to lower border of the tendon of the teres major.

Line is from the middle of clavicle to the junction of the anterior and middle third of outer wall of axilla.

Operation.—*First Portion:* The incision, 5 to 7 cm. long, is made parallel with and 2 cm. below the middle third of clavicle, dividing the skin, fascia, and the clavicular portion of the pectoralis major. The costocoracoid membrane below the subclavius, and pectoralis minor is incised and drawn downward. The needle is passed from below upward, avoiding the vein lying below and to the inner side, the brachial plexus lying above, and to the outer side, and the thoraco-acromial artery and cephalic vein. *Third portion:* The arm is abducted, and a longitudinal 7-cm. incision made along the lateral border of the axilla over the medial border of the coracobrachialis, dividing the skin and fascia. The medial head of the median and the medial antibrachial cutaneous nerve (lying over artery) are retracted inward, and the musculocutaneous nerves (lateral to the artery) are drawn outward, and the vein, ulnar and medial brachial cutaneous nerves (lying medial to the vein) are separated. The ligature is passed from within outward.

Ligations near the axillary-brachial junction jeopardize the *collateral circulation*, as there is only one small collateral branch running from the posterior humeral circumflex to the profunda.

Indications.—(1) *Wounds* of the axillary artery; (2) *uncontrollable hemorrhage* from distal vessels, as a temporary measure; (3) *aneurysm* of the brachial, axillary, or subclavian artery. Above the thoraco-acromial the *collateral circulation* is similar to that after ligation of the third part of the subclavian through the intercostal anastomoses, as follows: The highest intercostal branch of the subclavian with the lateral branches of the aortic intercostals, the intercostal branches of the internal mammary with the thoracic and subscapular branches of the axillary, the superior epigastric branch of the internal mammary with the inferior epigastric branch of the external iliac. In the scapular anastomosis, the transverse scapular and the descending branch of the transverse cervical arteries, derived from subclavian, communicate with the subscapular branch of the axillary.

Ligation of the third part of the axillary artery is the operation of choice. This portion has the subscapular and anterior and posterior humeral circumflex branches. The *second* has the thoraco-acromial and lateral thoracic branches, while the highest thoracic and sometimes the thoraco-acromial arise from the *first part.*

Results.—Gangrene follows ligation of the axillary artery in 8 per cent. of the cases. It is rare if both artery and vein are ligated.

Brachial artery extends from the axillary artery to the neck of the radius, where it divides into the ulnar and radial arteries. It lies under the mesial border of the coracobrachialis and biceps, above and in a groove between the brachioradialis and pronator teres below.

Anteriorly lies integument, lacertus fibrosus and, in the midportion, the median nerve; *posteriorly above*, the radial nerve; and *below*, the arteria profunda brachii, the medial head of triceps muscle, insertion of coracobrachialis and brachialis; *laterally*, the coracobrachialis and median nerve above, below with the biceps; *medially*, medial antibrachial cutaneous and ulnar nerves and basilic vein above, and the median nerve below.

Branches are the profunda brachii, superior ulnar collateral, inferior ulnar collateral, nutritent, muscular, radial, and ulnar.

Line extends from the junction of the middle and anterior third of the lateral border of the axilla, to a point midway between the two condyles of the humerus.

Muscular guide is the medial border of biceps.

Operation.—*Point of election* is the middle third of the arm. A vertical, 5 to 7 cm. long incision is made along the medial border of biceps, which is retracted laterally, the ligature being passed medial to the overlying median nerve.

Ligation also may be performed at the bend of the elbow, under the lacertus fibrosis (bicipital fascia) which is partially divided. The needle is passed from within, avoiding the ulnar and median nerves.

Collateral circulation, after ligation at the middle of the arm, by the profunda brachii and superior ulnar collateral branches, around the elbow to the inferior ulnar collateral, the radial and ulnar recurrents, and the dorsal interosseus.

Indications.—Secondary hemorrhage from the artery or in its area of distribution, particularly in the palm of the hand when local measures fail.

Radial and Ulnar Arteries.—Formal ligation of these vessels is rarely desirable. The *radial artery* continues into the deep volar arch, the *ulnar artery* into the superficial and deep volar arches; they anastomose so freely that ligation of a single artery is not effective in controlling hemorrhage. Rarely, both ulnar and radial are ligated at the wrist for hemorrhage from the palmar arches.

1. **Radial artery** runs between the tendons of the brachioradialis on the radial and the flexor carpi radialis on the ulnar side, and is associated with two venæ comites and the superficial branch of the radial nerve, all of which are to be avoided.

Line.—From the middle of the cubital fossa and neck of the radius, to the front of the radius between the brachioradialis and flexor carpi

radialis tendons, the artery continuing downward to form the deep palmar arch.

Muscular Guide.—The ulnar border of the brachioradialis.

Ligation of Upper Third.—A 5- to 7-cm. incision is made in the line of the vessel, the brachioradialis retracted laterally, the needle passed from the radial side or side of radial nerve. **At the Side of the Wrist:** In the anatomic snuff-box (*la tabatière*), which is bounded anteriorly by the tendon of the extensor pollicis brevis and posteriorly by the extensor pollicis longus. *Line:* From the tip of the styloid process to the posterior angle of the first interosseous space.

Incision.—From the styloid process to the base of the first metacarpal bone, parallel with abductor pollicis longus. The radial nerve and vein run parallel to the extensors of the phalanges.

2. **Ulnar artery,** deeply situated above, in the lower forearm is covered only by skin and fascia, with palmar cutaneous branch of ulnar nerve anteriorly The tendon of flexor carpi ulnaris lies on the ulnar side, and the flexor digitorum sublimis on the radial side.

Line of the upper third curves from just below the middle of the cubital space on ulnar side of the forearm to the junction of the upper and middle third of the ulna, whence it passes along a line from the apex of the medial condyle of the humerus to the radial side of the pisiform bone. Adjacent venæ comites, and the ulnar nerve, lying to the ulnar side of artery, should be avoided.

Muscular guide is the radial border of flexor carpi ulnaris.

Ligation at Middle Third.—*Incision:* Six to 10 cm. long over the line of the vessel, dividing the skin, superficial and deep fascia, and separating the flexor carpi ulnaris from flexor digitorum sublimis. At *the wrist* the incision is carried along the radial border of the flexor carpi ulnaris, the ligature being passed from the ulnar side to avoid the ulnar nerve.

Abdominal Aorta.—While the *collateral circulation* is sufficient, after the ligation of the abdominal aorta below the renal arteries, death (except in one instance) has followed the occlusion of the aorta by ligature or metallic band. One of the first 20 patients lived for forty-eight and another for thirty-nine days, the artery eventually giving way from necrosis or ulceration at the point of ligature or occlusion. The kidneys may fail to function, from the low arterial pressure produced by ligation above the renals. Probably division of the aorta between ligatures is safer than ligation in continuity. The artery thickens, and retracts 2 or 3 cm. after division. The abdominal aorta lies behind the peritoneum in contact with the upper four lumbar vertebræ, the inferior vena cava to the right. At the level of the lower border of the fourth lumbar vertebra, to the left of the middle line, or a finger's breadth below and to the left of the navel, it divides into the right and left common iliac arteries. The lowest visceral branch is the inferior mesenteric artery, $3\frac{1}{2}$ cm. above the bifurcation.

Indications.—Aneurysm of the common iliac artery, involving the bifurcation; aneurysm of the abdominal aorta between the origin of the inferior mesenteric and the bifurcation. The patient is placed in the Trendelenburg position, a left vertical transrectus incision made, the intestines walled off by pads, the posterior parietal peritoneum incised from the left side of the aorta and the sympathetic plexus cleared. The ligature should be of heavy floss-silk.

Collateral circulation, with the ligature below the inferior mesenteric, is between the inferior mesenteric above and the internal pudendal below; the lumbar arteries above, and branches of the internal iliac below; the internal mammary above, and the inferior epigastric below.

Common iliac artery (5 cm. long) ends at the level of the lumbosacral articulation in the external iliac and hypogastric. Branches are small; they are peritoneal, subperitoneal, and ureteric. The two common iliac veins join behind the right artery to form the inferior vena cava, the left artery is crossed by the inferior mesenteric vessels.

Line: From the bifurcation of the aorta, a fingerbreadth below and to the left of the umbilicus, to a point midway between the anterior superior spine and pubic symphysis.

Indications.—Ligation has been performed for aneurysms of the external iliac not suitable for aneurysmorrhaphy, or as a preliminary to amputations about the hip-joint.

Operation.—1. *Intraperitoneal Method:* Trendelenburg's position, vertical left lower transrectus incision, centering just below the umbilicus. The intestines walled off by pads, the posterior parietal peritoneum opened over the artery, the needle passed from right to left on both sides. The veins lie behind the artery on the right side, and behind and medially on the left.

2. *Extraperitoneal Method: Skin incision* 2 cm. above and parallel with Poupart's ligament, extending outward to a point near the tip of the cartilage of the eleventh rib. The abdominal muscles are separated or divided, the peritoneum exposed and pushed upward and inward. The *deep muscular guide* is the inner border of the psoas major.

Collateral Circulation.—(1) Between the hemorrhoidal branches of the inferior mesenteric above, and the hemorrhoidal branches of the hypogastric below. (2) Uterine, ovarian, and vesical arteries on both sides. (3) The middle sacral branch of the aorta above, and the lateral sacral branches of the internal iliac below. (4) The internal mammary, lower intercostals and lumbar arteries above, and the inferior epigastric below.

Hypogastric (Internal Iliac) Artery.—Three and one-half cm. long, passing from the sacro-iliac synchondrosis into pelvis to the upper border of the great sciatic notch, when it divides into an anterior and a posterior trunk. The ureter is anterior, the vein behind the artery, and the lumbosacral cord more posterior.

The *anterior trunk* supplies the pelvic organs, generative organs, and thigh through the hypogastric, superior, middle and inferior vesical, the middle hemorrhoidal, uterine, vaginal, obturator, sciatic, and internal pudic; the *posterior trunk*—the muscles of the hip and sacrum through the iliolumbar, lateral sacral, and gluteal.

Indications.—Preliminary to panhysterectomy or excision of the rectum, for malignant growths of the pelvis, hemorrhage, or gluteal aneurysm.

Operation is similar to that for ligation of the external iliac.

Collateral circulation: (1) Gluteal and sciatic above, with deep circumflex iliac and branches of the profunda femoris below; (2) branches of the obturator and pudic arteries of the two sides; (3) middle sacral above, and lat-

eral sacral below; (4) inferior mesenteric above, with the hemorrhoidal arteries below.

Superior Gluteal Artery.—A continuation of the posterior division of the hypogastric, from the upper part of the greater sciatic foramen to the space between gluteus medius and piriformis, and to branches under the gluteus maximus. *Line:* From the posterior superior iliac spine to the upper border of the great trochanter, the artery emerges opposite the junction of upper and middle third of the this line.

Incision, along the line of the artery, the fibers of gluteus maximus being separated, the deep fascia opened, and the artery exposed by separating the gluteus medius from the piriformis.

Inferior gluteal (sciatic) artery, the anterior division of the hypogastric, emerges at the lower part of the greater sciatic foramen, entering the buttocks below the piriformis, passing downward behind and to the inner side of the sciatic nerve, under cover of the gluteus maximus. It supplies the pelvic muscles and viscera, and without the pelvis gives off muscular, coccygeal, comites nervi ischiadici, anastomotic, articular, and cutaneous branches.

Line.—From the posterior inferior iliac spine to the ischial tuberosity.

Line of Incision.—Parallel to but 4 cm. below that for the superior gluteal artery. The skin and fascia are divided, the fibers of the gluteus maximus split, the artery located as it emerges from the greater sciatic foramen at the lower border of piriformis, just below the great sciatic nerve. The *internal pudendal artery* is also reached through the same incision.

External Iliac Artery.—Line: The lower two-thirds of a line from 2 cm. below and to the left of the navel, to a point between the anterior superior spine and the symphysis pubis.

Indications.—*Femoral aneurysm*, too high for ligation of the common femoral; *hemorrhage* in the distribution of the femoral.

Operations.—1. *Transperitoneal Operation:* A 7-cm. vertical, lower transrectus or pararectus *incision* is made with the patient in Trendelenburg's position. The intestines are walled off by pads, the peritoneum overlying the vessel divided, and the ligature passed from within out, avoiding the ureter (which crosses the artery near its origin) and, on the mesial side, the vein. On the left side the mesocolon overlies the artery, and the parietal peritoneum should be split vertically near the midline and stripped laterally.

2. *Extraperitoneal Operation:* A 10-cm. *incision* is made a fingerbreadth above and parallel with the outer part of Poupart's ligament, dividing or separating the external oblique, the internal oblique and the transversalis, immediately above the ligamentum inguinale. The peritoneum is raised from the brim of the pelvis, upward and medially, until the artery is exposed. The femoral nerve is lateral; the external spermatic branch of the genitofemoral nerve, anterior; while the vein lies somewhat posterior to the artery above, and medial to it below.

Deep Guide: Medial border of the psoas major, along which the vessel runs. The needle is passed from the medial side to avoid the vein. The inferior epigastric and deep iliac circumflex arteries should be preserved for collateral circulation.

Collateral Circulation Depends Upon: (1) The iliolumbar branch of the internal iliac above, and the iliac circumflex below; (2) the superior gluteal, with the lateral femoral circumflex, the obturator above, with the medial femoral circumflex; the inferior gluteal and circumflex, with the first perforating branches of the profunda below; (3) the internal pudendal above, and deep external pudendal below; (4) the internal mammary intercostals and lumbar arteries above, and the inferior epigastric below.

Femoral Artery.—Line: From a point midway between the anterior superior spine and the symphysis pubis, to the medial condyle of the femur. *Muscular Guide:* The sartorius, which is lateral in the upper third, anterior in the middle third, and medial to the artery in its distal third.

Points of Ligation.—(A) Base of Scarpa's triangle; (B) apex of Scarpa's triangle, and (C) in the adductor (Hunter's) canal.

A. *Base of femoral (Scarpa's) trigone*, just below Poupart's ligament—the undesirable point of ligation. *Line* is from a point midway between anterior superior spine and symphysis pubis, to the adductor tubercle of the medial condyle of the femur. The upper two-thirds of this line are over Scarpa's triangle. A 5-cm. transverse *incision*, or one following the line of the artery, is used. The skin, superficial fascia, and femoral fascia are divided, lymph-nodes and veins being avoided. The needle is passed from within outward, or from the side of the vein.

Collateral circulation may be insufficient, and is less than that following ligation of the external iliac.

B. *In Femoral (Scarpa's) Trigone.—Incision*, 5 cm. long, in the line of the artery. The great saphenous vein lies on the fascia to the medial side of the incision, the medial branch of the anterior femoral cutaneous nerve crosses the artery at this level. *Deep guide* is the mesial edge of the sartorius, which is located and retracted laterally, exposing the sheath of the artery. The femoral vein lies on the mesial side, the saphenous nerve deeper and to the lateral side, while other branches of femoral nerve lie under cover of sartorius. The needle is passed from within outward.

Collateral circulation after ligation below the profunda femoris depends upon: (1) Branches of the profunda and external circumflex above, and lower muscular and anastomotic branches of the femoral below; (2) the superior genicular branches of the popliteal, and the anterior recurrent tibial below; (3) the perforating and terminal branches of the profunda above, and the muscular branches of the femoral with the muscular and superior genicular branches of the popliteal below.

C. *Adductor (Hunter's) Canal.*—A 7- to 10-cm. incision is made in the line of the artery from the apex of the femoral triangle. The skin and fascia lata are divided, the Sartorius retracted mesially, exposing the fibrous roof of the adductor canal running from the adductores longus to the vastus medialis. The sheath of vessel is opened, avoiding the saphenous nerve which lies upon the sheath crossing from the lateral to the medial side. The needle is passed from without inward, to avoid the femoral vein which lies behind and to the lateral side.

Collateral circulation is similar to that after ligation at the apex of the femoral triangle.

Prognosis.—Gangrene follows ligation of the femoral artery in 20 per cent. of the patients. This is reduced to 9 per cent. by ligation of both artery and vein (Sehrt).

Popliteal artery extends from the opening in the adductor magnus at the junction of the middle and distal thirds of the thigh to the lower border of the popliteus muscle, or the level of the neck of the fibula and the lower part of the tuberosity of the tibia.

Line.—From a point 2.5 cm. medial to the upper angle of the popliteal space, passing midway between the condyles of the femur to the apex of the lower angle of the space.

Muscular Guide.—(1) *Upper third*, the inner border of the semimembranosus. (2) *Lower third*, the heads of the gastrocnemius between which the artery lies. The vessel is deeply placed, in contact with the trigone of the femur and the popliteus muscle. The tibial nerve and popliteal vein lie superficial to the artery, and cross the vessel from the lateral to the medial side. The vein lies between the artery and the nerve. The common peroneal nerve is well to the lateral side, on the medial side of the biceps femoris.

Ligation of the First Part.—Knee flexed and abducted; *incision* parallel with and a little behind the round tendon of the adductor magnus, from the junction of the middle to the lower third of the thigh, toward the adductor tubercle; avoiding the saphenous vein, which lies in the line of incision. The deep fascia is divided, the anterior border of sartorius drawn backward, the tendon of the adductor magnus cleared, and the separation carried between it and the sartorius to the artery lying against the femur. The vein is behind the artery, slightly to the lateral side, and the tibial nerve still more posterior. An incision may be made along the lateral border of the semimembranosus, which is retracted medially, the tibial (internal) popliteal nerve displaced laterally, the needle passed from without inward, the vein being slightly external.

Lower Part of Popliteal Artery.—A vertical incision is made in the midline of the popliteal space, opposite the level of the knee-joint. The artery is exposed between the heads of the gastrocnemius, the vein and nerve displaced medially, and the needle passed from within outward, or from the side to which the vein has been retracted.

Collateral circulation is poor; the lateral femoral circumflex and anastomotic branches of the femoral, and superior lateral genicular branches of the knee from the popliteal above, uniting with the inferior genicular and anterior and posterior tibial recurrent branches below. Gangrene follows ligation in about one-half of the cases.

Anterior Tibial Artery.—Line: From a point midway between the lateral tuberosity of the tibia and the head of the fibula, to a point on the front of the ankle midway between the two malleoli.

Muscular Guide.—The lateral margin of tibialis anterior in *upper third* of leg. *Incision* is in the line of the artery, which is found between the tibialis anterior and the extensor digitorum longus upon the interosseous membrane; the deep peroneal nerve lying laterally. The needle is passed from without inward.

Upper Third.—The artery is exposed between the tibialis anterior and the extensor hallucis longus. The deep peroneal (anterior tibial) nerve, lying in front of the artery and slightly to the fibular side, should be retracted outward; the needle passed from without inward, avoiding the interspace between the extensor digitorum longus and the perinæus longus, which is shown by a white line from a deposit of fat.

Middle Third.—In the space between the tibialis anterior and the extensor digitorum longus, the extensor hallucis longus is exposed with the artery to its medial side. The artery lies under cover of the fibers of the tibialis anterior, with the nerve to its fibular side.

Lower Third.—*Incision* is made between the lateral edge of the tendon of the tibialis anterior and the tendon of the extensor hallucis longus. The extensor hallucis longus is retracted laterally, the artery exposed with the nerve to its lateral side, the needle being passed from without inward.

Dorsalis Pedis Artery.—Line: From the midpoint between the malleoli, to the upper end of the interosseous space between the first two metatarsal bones, or to the proximal end of the first intermetatarsal space.

Guide is the tendon of the extensor hallucis longus which lies to its medial side, the deep peroneal nerve being lateral.

Incision (4 cm. long) along the lateral border of the extensor hallucis longus, which is retracted medially and the extensor digitorum brevis laterally, the needle being passed from the nerve on the lateral side.

Posterior Tibial Artery.—Line: From the center of the lower margin of the popliteal space, to the midpoint of the hollow behind the medial malleolus or a fingerbreadth behind the medial malleolus.

With the leg flexed and lying on the fibular side, for ligation of **upper part** (or above the peroneal branch) an 8 to 10 cm., vertical, median *incision* is made, beginning opposite the level of the head of the fibula, avoiding laterally the small saphenous vein and the medial sural cutaneous nerve, which are retracted laterally. The raphé between the heads of the gastrocnemius is divided, the lateral head of gastrocnemius retracted, the tendon of plantaris and lateral border of soleus exposed, the plantaris retracted and upper fibers of soleus divided, exposing the artery lying upon the tibialis posterior muscle. It is accompanied by venæ comites, and the tibial nerve lies on the medial and posterior sides. The needle is passed from without inward.

Middle Third of Leg.—*Incision:* A vertical 10-cm. incision, a fingerbreadth behind the medial border of tibia is made, avoiding the great saphenous vein and saphenous nerve. The medial border of gastrocnemius is retracted, the oblique fibers of the soleus divided from the tibia, exposing the fascia and separating the superficial from deep calf-muscles. The fascia is incised, exposing the flexor digitorum longus; the artery being found on the tibialis posterior, about 3 cm. from the medial border of the tibia, the tibial nerve lying on the lateral side. The needle is passed from without inward.

Lower Third.—*Incision:* Vertical 5-cm. incision through the skin and deep fascia, a fingerbreadth behind the inner edge of the tibia, in the groove between the flexor digitorum longus and the medial border of the soleus, avoiding the great saphenous vein and saphenous nerve. The needle is passed from

without inward, resuturing the laciniate (internal annular) ligament, and avoiding the tendon-sheaths.

Peroneal Artery.—Line: From the posterior border of head of fibula, to a point where the lateral border of tendo calcaneus is inserted into the calcaneus. *Incision:* Vertical, 7 cm. long, along the line of the artery, the soleus being retracted medially and the flexor pollicis longus divided close to the bone: the aponeurotic structures covering the vessel are divided, exposing the artery close to the fibula. The needle may be passed in either direction.

CHAPTER XXXI

AMPUTATIONS

Amputation is the removal in continuity of a part or an entire limb. While usually applied to the amputation of the extremities, the term also refers to the removal of the breast or penis. The term "amputation" is at times restricted to removal of a limb between joints, separation through a joint being given the name *disarticulation* or *exarticulation.*

Historical.—Simple transverse division of a limb was practised by Celsus and the Ancients. Ambroise Paré (1552) discarded boiling oil and the cautery in treating amputation stumps, and revived the ligation of vessels for the control of hemorrhage. In the eighteenth century Petit introduced the tourniquet, although constriction of a limb to prevent hemorrhage had been used by Antyllus and other ancient surgeons.

Classification.—Amputations are divided: A. **According to urgency** into (1) those of *choice* or *election*, and (2) those of *necessity.*

B. **As to Time:** (1) *Congenital* or *spontaneous*, those present at birth and produced by amniotic adhesion of other cause. (2) *Primary*, the part being removed within the first twenty-four hours; this is the period of shock and great danger in extensive operations. (3) *Intermediate*, between the first twenty-four hours and the fourth day, the amputation being required during this time usually for infection or hemorrhage. (4) *Secondary or Consecutive Amputation:* Performed after the fourth day for hemorrhage, infection, or to remove a useless or disfiguring member.

C. **As to Skin Flap:** (1) *Flap amputations.* (2) *Flapless*—Celsus, chop or guillotine—amputations.

As to Shape of Flap: (1) *Circular.* (2) *Modified circular*, with lateral vertical incisions. (3) *Oval* or *elliptic.* (4) *Racket*, shaped like a tennis racket. (5) *Anteroposterior* flaps or lateral flaps. The flaps may be rounded, oval, or rectangular, and of equal or unequal length. *Teale's amputation*, which is rarely used, consists of one short and one long rectangular flap.

D. **As to Periosteum:** (1) *Periosteal:* Before the bone is divided a flap of periosteum is formed, which is used to cover the end of the divided bone. As this may give a sensitive stump with a growth of osteophytes the (2) *aperiosteal* or *Bunge's amputation* is routinely used, the periosteum being removed from the last 1 or 2 cm. of the bone, and the end of the bone smoothed and contoured.

E. **As to Location:** (1) In *continuity*, amputation through a bone. (2) In *contiguity* (or disarticulation), amputation through a joint.

F. **As to Gravity:** (1) *Major amputations*, those above the wrist or ankle. (2) *Minor amputations*, through, or below the wrist or ankle.

G. **As to Number:** (1) *Double, triple, quadruple.* (2) *Bilateral.* (3) *Synchronous amputations* are multiple amputations performed at the same time by two or more operators.

H. As to Bone: *Osteoplastic Amputation:* A layer of attached bone, covered by periosteum, is placed over the divided bone-ends to ensure an end-bearing stump, as in Gritti-Stokes, and Chopart's amputations. Osteoplastic amputations have a limited use, and give little better end-bearing function than a well-formed aperiosteal stump.

I. As to Cause: (1) *Traumatic*, produced by accident. (2) *Pathologic*, from disease, as in senile gangrene.

Cinematic or Cineplastic Amputation (Vanghetti, 1896).—A method to provide direct transmission of voluntary movement from the muscles of the stump to the artificial limb. Artificial points of attachment are made to the muscles of the stump (*plastic motors*), from which cords transmit movement to the artificial appliance. A division is made into: (a) the *club* (*clava*), (b) *loop* (*ansa*), (c) or *tunnel motors* through the muscular masses.

In the *club motor*, by dividing the bone just above the stump and producing a false joint, a knob-like end to the stump is produced, which may voluntarily be moved by attached muscles in various directions and convey power through an encircling band or ring. In the *loop motor* the tendons and muscles form a loop for the attachment of rods or cords.

In the *tunnel motor* a channel is made through the muscle, which is lined by skin through which a rod or cord may be worn to transmit power.

Artificial arms and hands are now supplied, moved by cords running from the shoulder or thorax. These have largely rendered cineplastic amputations, with the additional plastic operations and prolonged treatment and education required, unnecessary.

Indications.—A. General: The removal of a part useless, disfiguring, or harmful to life. Amputation may be performed:

1. *To save life*, milder measures failing, when threatened by infection, poison (snake-bite), gangrene, necrosis, hemorrhage, or malignant tumor.

2. *To Increase Function:* (a) The removal of a useless, troublesome or supernumerary part; (b) to provide a stump suitable for the fitting of a useful prosthesis.

3. *For Cosmetic Improvement:* An artificial functionless limb may be preferred to unsightly useless one.

B. Special: 1. Extensive *comminution of bone*, with laceration of large vessels and nerves.

2. Such extensive *destruction of muscles* as to render the part functionally useless.

3. Such extensive *destruction of skin* that the replacement by epithelization, skin-grafting, or transplantation is impossible.

4. *Division of the main vessels* of arm or thigh, or both vessels of forearm or leg, usually, but not invariably, indicates amputation.

Division of a *single vessel* of the forearm or leg should be treated by conservatism.

Primary amputation may be performed under psychical shock which improves under an anesthetic, but should not be performed in anemic or secondary shock until reaction has occurred. In case of doubt as to the vitality of the injured part, it should be cleansed, disinfected, the divided vessels ligated, and a volu-

minous moist, warm antiseptic dressing (boric alcohol; 1 : 4000 bichlorid) applied. The part is elevated, and kept warm and wet, and amputation used on evidence of gangrene or dangerous infection.

For badly crushed parts, to prevent strangling by the skin tension, *free longitudinal incisions* should be made before the secondary swelling has cut off the circulation. No tissue that shows any evidence of viability should be removed from the fingers or hand. A surprising restoration often occurs in hands and fingers, crushed, comminuted, or partially pulpefied as by passing through cog-wheels.

Delay as to amputation is more dangerous with the lower extremities than the upper. Amputations through the thigh and leg cause more shock than through the arm and forearm.

Amputation Stumps.—(1) *Support:* For the leg, a direct end-bearing stump gives the best support, an indirect or lateral bearing stump requires more care, the skin being more often irritated or ulcerated from pressure. (2) *Stability* that is obtained with the artificial leg varies directly with the length of the stump and limb, and with the thickness of the soft tissues over the bone. With a short stump the stability is less, and may require the fixation of the joint of the artificial limb at the hip or knee. (3) *Progression* or successful walking depends upon the ability to use natural joints, upon muscular power, sufficient leverage (sufficiently long stump), and painless bearing of the prosthesis. With a short stump walking produces fatigue, which may be decreased by reducing the weight of the artificial limb. (4) *Appearance* of the stump is of minor importance. To a laborer a rough, strong, functional stump is better than a well-contoured part of little function, which latter might be preferred by a woman or man of sedentary habits. Where the patient cannot afford an artificial limb, an end-bearing stump of as great length as possible should be provided.

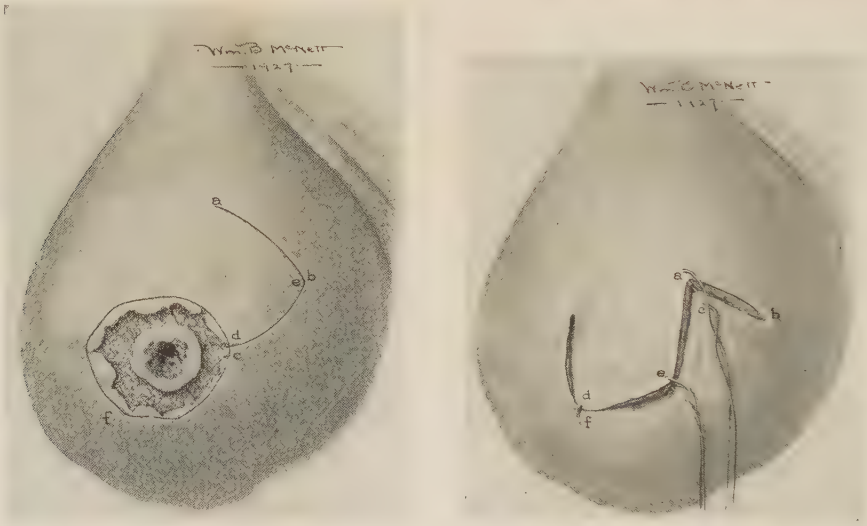
Cicatrix.—To prevent irritation from pressure, the scar should be *terminal* for the arm and forearm, *dorsal* for the foot, toes and fingers, *lateral* or *termino-lateral* for the leg and thigh.

Affections of Amputation Stumps.—(1) *Secondary hemorrhage.* (2) *Ulceration*, sloughing, and retraction of the flaps. (3) *Osteitis* or septic osteomyelitis. (4) *Sinus formation.* (5) *Conical Stump:* After amputation through the upper third of the humerus, and upper part of the femur in children, the bone may continue to grow, forming a conical stump necessitating reamputation. (6) *Painful stump.* (7) *Neuralgia* of the stump. (8) *Jerking*, or *neurotic stump.* (9) *Adherent Skin:* A thick covering of soft tissue over the bone is desirable for weight bearing. An excess of soft tissue with flabbiness causes instability. The stump should be firm and resistant. A large or bulbous ended stump (such as follows disarticulation) necessitates a lacing socket, is less convenient for the application of an artificial limb, and does not provide sufficient space for the joint-mechanism, although certain manufacturers use the bulbous end to retain the prosthesis.

If the scar is subjected to direct pressure or is adherent to the bone, it may ulcerate. From pressure, a bursa often forms over the bone. Exposed bone and retracted muscles may necessitate reamputation. Chronic or recurrent ulcers of the trophic type should be treated by reamputation or periarterial sympa-

thectomy (Leriche). Painful bony spurs from the imperfect removal of periosteum should be excised with the adjacent periosteum, and the end of the bone contoured. Contractures may be troublesome after amputation through the thigh, leg, or through the midfoot as in Chopart's operation. Contractures interfering with the use of artificial limbs should be prevented by early stump-exercises, massage and passive movements, traction, tenotomy, splinting, and especially the early use of a provisional prosthesis. Infection may lead to bone necrosis and the formation of a ring or circular sequestrum of the lower end of the bone, which should be removed or the bone reamputated. Conical stump, if sensitive or troublesome, should be treated by plastic operation or reamputation.

Amputation neuroma may be the cause of much paresthesia (*phantom foot, phantom hand*) or neuralgic pain. The nerve-trunk above the neuroma should



Figs. 476, 477.—Kirk's plastic operation for covering the exposed bone after a guillotine amputation by rotation of a flap.

be injected with alcohol, or the neuroma excised and the open nerve end closed by plastic operation so as to bring the divided axis-cylinders into apposition with each other.

Lengthening of the Stump.—By raising adjacent folds of skin or muscle, additional length is secured for moving the artificial limb. With the *humerus*, the pectoralis major may be divided at its insertion to raise the anterior axillary fold. Removal of muscles from the condyles of the humerus, which push the socket from an 8 or 10 cm. stump when the elbow is flexed, is suggested by Openshaw.

Skin-grafting rarely is desirable, except with the fingers, as the thin grafts are not sufficiently durable under stress; but pedicled flaps may be transplanted to the stump, especially to the hand or finger. Such pedicled flaps may lengthen the stump, and may greatly increase the usefulness of the part.

Reamputation should not be done during the period of active inflammation

or brawny induration. Swelling and edema and, especially, evidences of active infection, should have been absent for several months. All open sores and ulcers are to be treated by a saturated solution of chlorid of zinc or other efficient antiseptic, just before the reamputation is performed.

Instruments Required for Amputation.—Esmarch's rubber bandage, large and small scalpels, thumb forceps, hemostatic forceps, a saw, Liston's bone-cutting forceps, rongeur, and bone rasp or coarse file. The long amputating knives of Liston, unless an amputation by transfixion is to be done, the double-edged catlin (for dividing tissues between two bones, as in the forearm and leg), Wyeth's pins, Lynn-Thomas forceps, or special tourniquets are rarely necessary. A carpenter's fret or scroll-saw for smaller bones, and an inexpensive hack- or meat-saw for the larger bones will suffice.

Technic.—The combined length of the flaps should be one and one-quarter times the diameter of the limb, or about one-half the circumference of the limb at the point of amputation, to allow for contraction and retraction of the soft tissues.

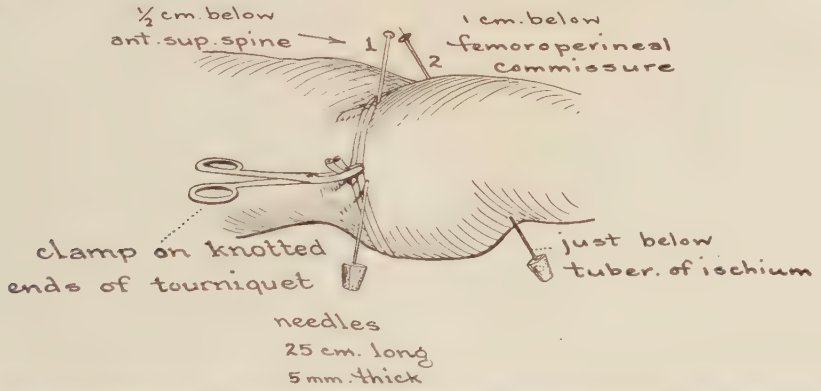


Fig. 478.—The application of Wyeth's pins and tourniquet for disarticulation of the hip. With the preferred enucleation type of amputation Wyeth's pins are unnecessary.

Amputation with a Tourniquet.—The limb is first emptied of blood by elevation or, if there is no septic or malignant disease, by applying an Esmarch rubber bandage from the toes or fingers to a point well above the plane of amputation. The tourniquet (preferably many turns of the soft rubber bandage) is applied over 4 turns of a soft roller bandage, and the Esmarch bandage removed. The limb should now be bloodless. If the amputation is to be near the trunk, Wyeth's pins or other devices were formerly often used to prevent the slipping of the tourniquet or to maintain hemostasis.

Circular Amputation.—A short or long Liston amputating knife or a scalpel is used. The skin of the limb is retracted toward the trunk, and at a distance three-fourths the diameter of the limb below the point of proposed bone section, the incision is carried through the skin, superficial and deep fascia, encircling the limb. The skin and fascia are reflected upward for 2 to 4 cm., and a circular incision made through the remaining soft parts to the bone, the soft parts retracted, the periosteum encircled and scraped away by a periosteal separator, from a point 2 cm. above to the line of bone section; the bone divided by the saw, the

marrow removed from the lower end of the bone, and the bone contoured by cutting forceps, rasp, or file to remove sharp and projecting edges. The nerve-trunks are pulled from their sheaths and divided, fish-tail fashion, at a high position after injection with 85 per cent. alcohol, to prevent the formation of painful neuromas. All blood-vessels are ligated, and the tourniquet (if it has been used) gradually loosened and removed. Moderately thick layers of muscle and aponeurosis are united over the bone, to obliterate dead spaces and to prevent adhesion between the bone and the skin. The skin is united, converting the circular into a transverse wound. A small tube-drain is introduced between two stitches, and left for twenty-four or forty-eight hours. A copious dressing is applied, and adhesive-plaster traction used upon the skin to prevent undesirable retraction. The circular amputation gives a terminal transverse scar (not objectionable with the arm) with the greatest conservation of tissue, but less perfect exposure of the bone and soft tissues than the flap operation.

Modified Circular Amputation.—Where the limb is conical (and sufficient exposure is not obtained by the circular incision) two additional lateral incisions are made through the skin, forming two quadrilateral flaps, the corners of which may be rounded.

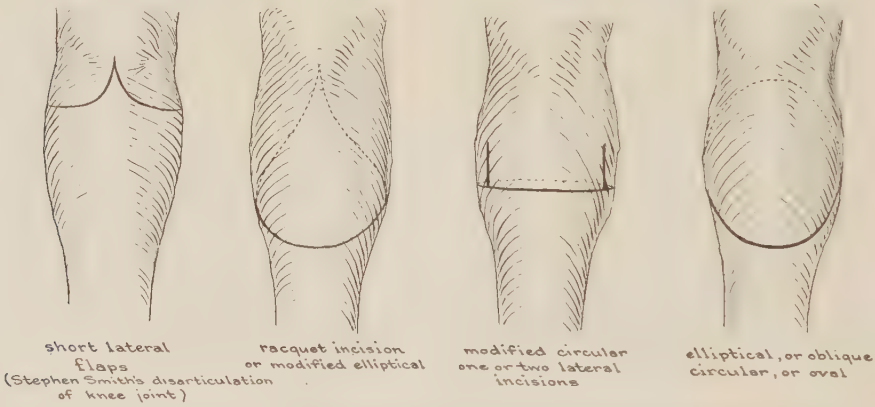

short lateral flaps
(Stephen Smith's disarticulation of knee joint)
racquet incision or modified elliptical
modified circular one or two lateral incisions
elliptical, or oblique circular, or oval

Fig. 479.—Stephen Smith's racquet, modified circular, and elliptical amputations of the leg.

Oblique Amputation.—A circular incision is made, passing through a plane oblique to the long axis of the limb; producing the effect of a long and short flap, with displacement of the scar so it does not overlay the bone. The ellipse extends from just above, to a point one and one-half diameters of the limb below the line of bone-section. The muscles are divided circularly, obliquely, or in the form of flaps.

The *racket incision* is a modification of the oval incision, resembling a tennis racket. The upper part of the oval extends as a straight incision running up the limb. The scar runs across the end and one side of the stump. It gives a very satisfactory exposure of the deep structures and bone, and is largely used for the fingers and toes.

Flap Amputation.—Flaps may be so formed as to be anterior, posterior, or lateral. They may be of equal length or be short and long, and either square or oval. Flaps may be formed: (1) From *without inward;* (2) from *within*

outward or by *transfixion*. In the transfixion method the knife passes through the median plane of the limb, close to the bone, and emerges at an opposite point on the other side of the limb. It then is made to cut down and out, forming a thick flap of skin and soft tissues. For the remaining flap the knife is reintroduced at the apex of the incision, carried about the other side of the bone, and the flap on the opposite side of the limb formed by cutting down and out. As flaps may be more accurately fashioned from without in, the method is rarely used at the present time except in instances where speed and minimum manipulation are important, as in types of senile and diabetic gangrene. This method is at times used without a tourniquet, the assistant's fingers following close behind the knife to compress the flap and vessels as they are divided.

Guillotine amputation may be performed in the shortest time, with least shock, at the lowest possible level, the best drainage, the least danger from pre-existing infection, and the least interference to the circulation of any amputation. It is especially used in gas gangrene, sepsis, local septic conditions.

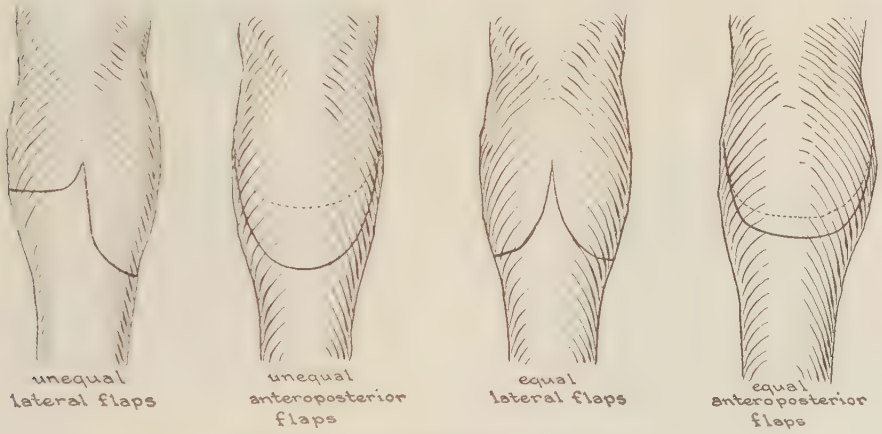


Fig. 480.—Flap amputations through the leg.

Technic.—The skin is pulled toward the body, and a circular incision made to the bone, transverse to the long axis of the limb; the bone is then sawed flush with the muscles, the vessels ligated, and the wound left fully open; moist or other dressing being applied to overcome infection. As soon as the danger of infection has passed, traction is made by weight and pulley to adhesive strips upon the skin, and the surface gradually becomes covered down to or partially over the bone. Reamputation and the formation of a suitable stump are performed after four or five days, where the primary amputation was done for shock or transient infection; after six weeks or more, where a persistent progressive infection is present.

Amputation by enucleation is usually preferred where careful hemostasis and accurate division of tissue is more important than the saving of time. The amputation is conducted as for the excision of a tumor, usually without a tourniquet, the structures being systematically exposed from without inward, each vessel being divided between ligatures as it is encountered. It usually is desirable to proceed from the side of the largest vessels, which are exposed and divided

early in the operation. This method is especially desirable where the traumatism of a tourniquet or Esmarch's bandage may be harmful (as in elderly or emaciated patients with arterial degeneration or obstruction, sepsis or malignancy), when local anesthesia is used, and where the amputation is performed close to or partially through the trunk. It gives the best evidence as to the circulation in the stump.

Position of the Scar.—The amputation should be so planned that the scar from the closure of the skin flaps is subject to the least possible pressure or irritation. As a rule, this is where the terminal and lateral surfaces of the stump meet. *With the arm and forearm* a terminal scar is preferable (circular, modified circular, or equal anteroposterior flaps being best) except at the wrist, where a palmar flap is very satisfactory.

Fig. 481.—Guillotine amputation through the thigh.

Fig. 482.—Spontaneous closure two months after guillotine amputation for gas gangrene in a boy of eighteen. Amputation under spinal anesthesia was followed by almost immediate improvement from advanced and apparently hopeless infection. Later reamputation to cover bone end (1910).

Covering the Bone.—Adhesion of the skin to the bone is undesirable and should be prevented by interposing muscle and fascia, which is sewn over the bone-ends without undue redundancy, as the soft tissues of the stump should be firm and not too movable upon the bone. The nerve-ends should be cut short, and injected with alcohol. The "fish-tail" method of Ritter is useful in preventing secondary neuromata.

Site of Amputation.—As a rule, the amputation should be at the *lowest possible level*. With amputations through the tarsus, however, this is objectionable, rendering it difficult to fit an artificial foot; while traction of the tendo calcaneus may cause an equinus displacement of the stump, necessitating a reamputation through the leg.

Disarticulation, while giving a bulbous stump for the better retention of

the artificial limb, is more difficult to fit and interferes with the placement of artificial joints. The cartilaginous covering of the bone, unless removed, may secrete synovial fluid and interfere with healing. As a rule, it is therefore best to amputate 4 or 5 cm. proximal to a joint, to give space for the artificial hinge and to remove articular cartilage.

Pylons.—As soon as firm healing has occurred, and all inflammation has subsided, it is desirable that an apparatus be applied for the exercise and development of the stump. Under use the stump shrinks, becomes firm, inured to end bearing, and the patient develops facility in using an artificial appliance. As the stump rapidly shrinks and changes its shape, inexpensive and easily formed pylons are desirable during this stage. After amputation of a single arm the appliance is of little value in the early stages of the treatment.

Methods.—Materials required are: Sheet-felt, $\frac{1}{4}$ inch thick, simple stump-frame of white pine (of the crutch type with a rubber heel), 5-inch plaster-of-

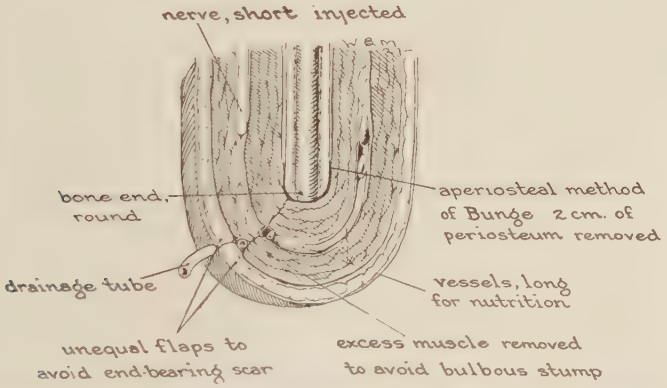

nerve, short injected
vein
bone end, round
periosteal method of Bunge 2 cm. of periosteum removed
drainage tube
vessels, long for nutrition
unequal flaps to avoid end-bearing scar
excess muscle removed to avoid bulbous stump

Fig. 483.—Desirable features in an amputation stump. The end of the bone should be smooth and rounded, free from periosteum, and covered by a thin layer of fascia and muscle. The nerves should be cut short and the ends injected with alcohol or treated by a plastic method. An end-bearing scar should be avoided. A drainage-tube is used for the first twenty-four or forty-eight hours.

Paris bandages, webbing and buckles for strap, and a few carpet tacks (modification of Le Page, by the Surgeon-General's office). The sheet-felt is trimmed, accurately fitted to the stump, and sewed in position. About the felt-lining the plaster bandage is snugly applied, the stock wooden frame and the straps of elastic webbing being incorporated between the layers of plaster. Several tacks driven into the top of the wooden frame increase the fixation. For the thigh, a thick pad of folded plaster-of-Paris bandage is fitted under the ischium and bandaged into place. When the plaster has hardened, the pylon is removed, the plaster permitted to dry, the rough edges around the margin of the socket smoothed, and the upper edges of felt turned down over the edges of plaster and glued into place. When (from shrinking of the stump) the socket becomes loose, the plaster is knocked off and a new socket made, to which the supporting frame is fitted.

As the patient should early resume movement of the knee and ankle a more

elaborate prosthesis (with an artificial foot and knee- and ankle-joint) is desirable after amputation through the thigh.

Special Amputations.—Hand: The hand and fingers have surprising viability. Severed portions of fingers may be cleansed and immediately reaffixed, with hope that union will occur. Fingers and hands apparently hopelessly crushed and pulpified often live under proper treatment. In case of doubt it is wise to cleanse the part, apply a copious wet dressing of boric alcohol or weak bichlorid solution, after making free vertical incisions through the skin where it is evident that secondary swelling will constrict the deeper tissues. An apparently hopelessly crushed hand may have the skin split and turned back from the dorsal and palmar surfaces of the fingers, and the hand immediately embedded under the skin of the anterior abdominal wall for an additional vascular supply.

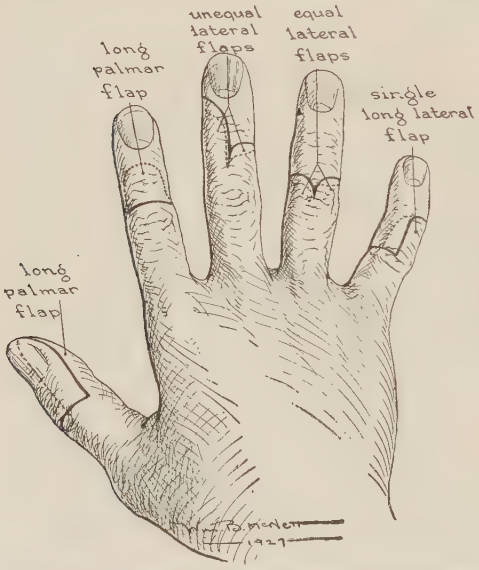


Fig. 484.—Incisions for amputations through the fingers and thumb. A palmar flap is preferred.

Where fragments of the fingers remain, these may be lengthened by embedding them in a pedicled fold of skin from the anterior abdominal wall. Instead of shortening the thumb or fingers by amputating with a formation of flaps, the amputated digit may be lengthened by transferring a pedicled flap. Where one or two terminal phalanges have been lost, the corresponding portions of a small toe may be transplanted by a two-stage operation. Every effort should be made to save as much of the thumb as possible.

Amputation of the Finger.—1. *Distal Phalanx:* With the finger strongly flexed, a transverse incision of the dorsum is made into the joint, the phalanx disarticulated, and a flap formed of the thick palmar tissues. It is to be recalled that the joints are about 1 cm. distal to the knuckles. This amputation gives a dorsal scar, and is very rarely necessary.

2. *Amputation* through the *proximal* or *middle phalanx*, or a *midphalangeal disarticulation*, is performed after the same plan, a palmar flap being preferred. The divided tendons should be reattached, and the bone divided with a fret-saw, rather than a cutting forceps, to avoid splintering. For disarticulation of the phalangeometacarpal and metacarpocarpal joint a racket incision is used, the transverse incision being on a line with the web of the finger and the longitudinal incision being dorsal. To render the hand more symmetrical, and to prevent undue separation of the remaining fingers, the head of the metacarpal bone may be beveled or excised, or the entire metacarpal bone removed. The more symmetrical appearance obtained by resecting the corresponding metacarpal is desirable in women, but for working-men greater

strength may be obtained by preserving the broader hand. Fingers with rigid or immovable joints, that are straight or flexed and cannot be restored by operation upon the tendons or joints, are usually in the way and for a working-man usually undesirable, and should be removed. With workmen, the efficiency of the resulting hand and the shortened period of disability may render a mutilating operation desirable, although such an operation would be avoided in a woman or a man of more sedentary habits. The thumb is the most valuable digit, and becomes very useful when a portion of the hand is preserved against which it can be apposed. Should the rest of the hand be lost, the thumb may be apposed against a fitted partial artificial hand. With removal of the metacarpals of the thumb or little finger, the muscles of the thenar and hypothenar eminences should be preserved if possible, and the bone removed subperiosteally, leaving a movable stump.

Amputation or disarticulation at the wrist should, if possible, be so planned as to save the thumb, and a finger or other portion of hand against which the thumb may be apposed. *Amputation* of the wrist *should be avoided*, as it prevents the proper fitting of an artificial hand with wrist-mechanism without undue length. Proximity to the wrist, however, preserves the power of pronation and supination, which in some cases is so valuable that a disarticulation at the wrist is favored, the bulbous end giving better but less convenient support for the artificial hand. The forearm may be removed from the lower third up to within 7 cm. of the elbow.

Forearm Amputations.—Anterior and posterior flaps of equal length are preferred. A circular or oval amputation also may be used. The deep fascia should be included with the skin flap, and the muscle divided at least 3 cm. below the point of bone division. Muscles and tendons should be sutured over the ends of bone, and covered by the deep fascia as a separate layer. A small rubber tube-drain is used for forty-eight hours.

To maintain pronation and supination in amputation through the forearm, synostoses between the radius and ulna should be prevented. If the forearm stump does not extend at least 4 cm. below the insertion of the tendon of the biceps, amputation above the condyle is preferable. With a short forearm stump, the biceps pushes off the stump socket when the elbow is flexed.

Elbow-joint.—Disarticulation is undesirable, as it produces a bulbous stump requiring an inconvenient laced socket, with interference with joint-mechanism in the artificial arm.

The *point of election* is 5 cm. above the elbow. Useful stumps are formed from immediately above the condyles to within 10 cm. of the shoulder, the longer stumps being preferable. In the arm, at least 5 cm. of stump below the axillary fold should be preserved to move the artificial arm. If this is not possible the stump may be lengthened by dividing the axillary fold, including the pectoralis major and teres minor. Anterior and posterior flaps are preferred, or a circular or oval amputation may be used. The muscles are cut $3\frac{1}{2}$ cm. longer than the bone.

Shoulder-joint.—If possible, the head of the humerus should be preserved to prevent unsightly flattening of the shoulder. Hemorrhage is prevented by ligating the axillary vessels under the coracobrachialis as the first step of the

operation, or the subclavian artery may first be exposed and a provisional clamp applied. With the Wyeth pin method, or figure-of-8 elastic constriction anchored under the opposite axilla, violent hemorrhage may occur as the bone is removed.

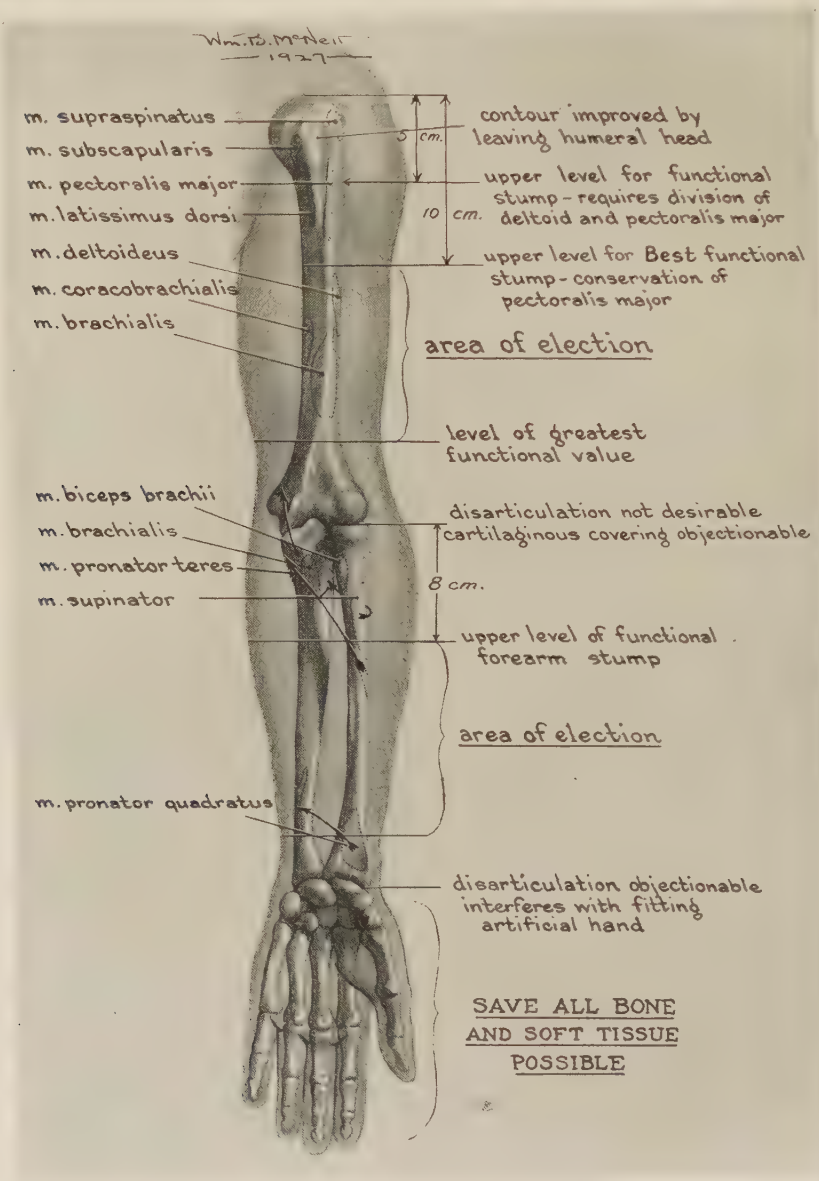


Fig. 485.—Amputations of the hand and arm in relation to function.

Anterior Racket (Spence's) Amputation.—Beginning midway between the coracoid and the acromion, an incision is made down the long axis of the arm for 10 cm., and then encircles the arm in racket fashion. The skin is reflected for several centimeters, the mesial muscles divided obliquely until the axillary vessels are exposed and ligated, the soft parts divided and separated

from the bone, with division of the capsule and the subscapularis. The head of the humerus is dislocated, the division of the capsule completed, and the remaining tissues on the mesial side divided; keeping close to the bone to avoid the posterior humeral circumflex artery and the axillary (*circumflex*) nerve.

External Racket (Larry's) Amputation.—From the tip of the acromion, a 15-cm. vertical incision is made down the lateral side of the arm. The oval incision begins at the center of the vertical and is carried obliquely around the arm. The flaps are first reflected from the outer side of the joint, the arm being removed as in the Spence operation.

Long external, short internal flap (Dupuytren's) amputation was often done in two minutes by the older surgeons. The base of the external U-shaped flap extends from the coracoid to the root of the acromion, the lowest point being at the insertion of the deltoid. The short internal flap extends .5 cm. below the axilla. The amputation was formerly done by transfixion, the outer flap being formed, the joint opened, the head of the humerus disarticulated, and then hemorrhage from the axillary vessels controlled by the fingers of an assistant, compressing the axillary vessels behind the moving knife as the inner flap was made.

Furneaux Jordan's Method.—A circular amputation is first made at the level of the lower fibers of the deltoid, and the bone divided at the level of the retracted soft parts. The vessels are secured, a vertical incision is made in the line of the intertubercular sulcus (bicipital groove), and the upper end of the humerus cleared and removed.

Interscapulothoracic amputation (Berger, 1887) includes the removal of the arm, scapula, and all or a part of the clavicle. From the sternal end, an incision is made over the clavicle, the periosteum of which is incised and the bone divided at the junction of its middle and inner third. The subclavius muscle and fascia are divided, exposing the subclavian artery which is ligated; the arm is raised, emptied of blood, and the subclavian vein then ligated. The brachial plexus is injected with procain solution and divided. The skin incision is extended from the middle of the clavicle, across the front of the shoulder and the anterior fold of the axilla, to the posterior axillary fold and inferior angle of the scapula. The pectoral muscles and the latissimus dorsi are divided, the limb drawn toward the opposite side, exposing the back, and the first incision from the middle of the clavicle continued over the scapula to the inferior angle. The trapezius, rhomboid, and omohyoid muscles are divided, and the upper extremity removed.

LeConte (1900) disarticulated the sternal end of the clavicle instead of dividing the bone. The operation is used for malignant disease of the shoulder.

Amputations of the Foot.—*Partial amputation of the four small toes* should be avoided, as the stumps become dorsiflexed and subject to pressure.

Metatarsophalangeal Amputation.—The metatarsophalangeal joints lie $2\frac{1}{2}$ cm. above the web. The racket incision is preferred—the oval encircling the toe at the level of the web, the handle of the racket extending at least $2\frac{1}{2}$ cm. along the dorsum of the metatarsal. The incision is carried to the bone, and the toe disarticulated while it is strongly dorsiflexed. Injury to the transverse metatarsal ligament uniting the heads of the metatarsal bones should be avoided. To remove

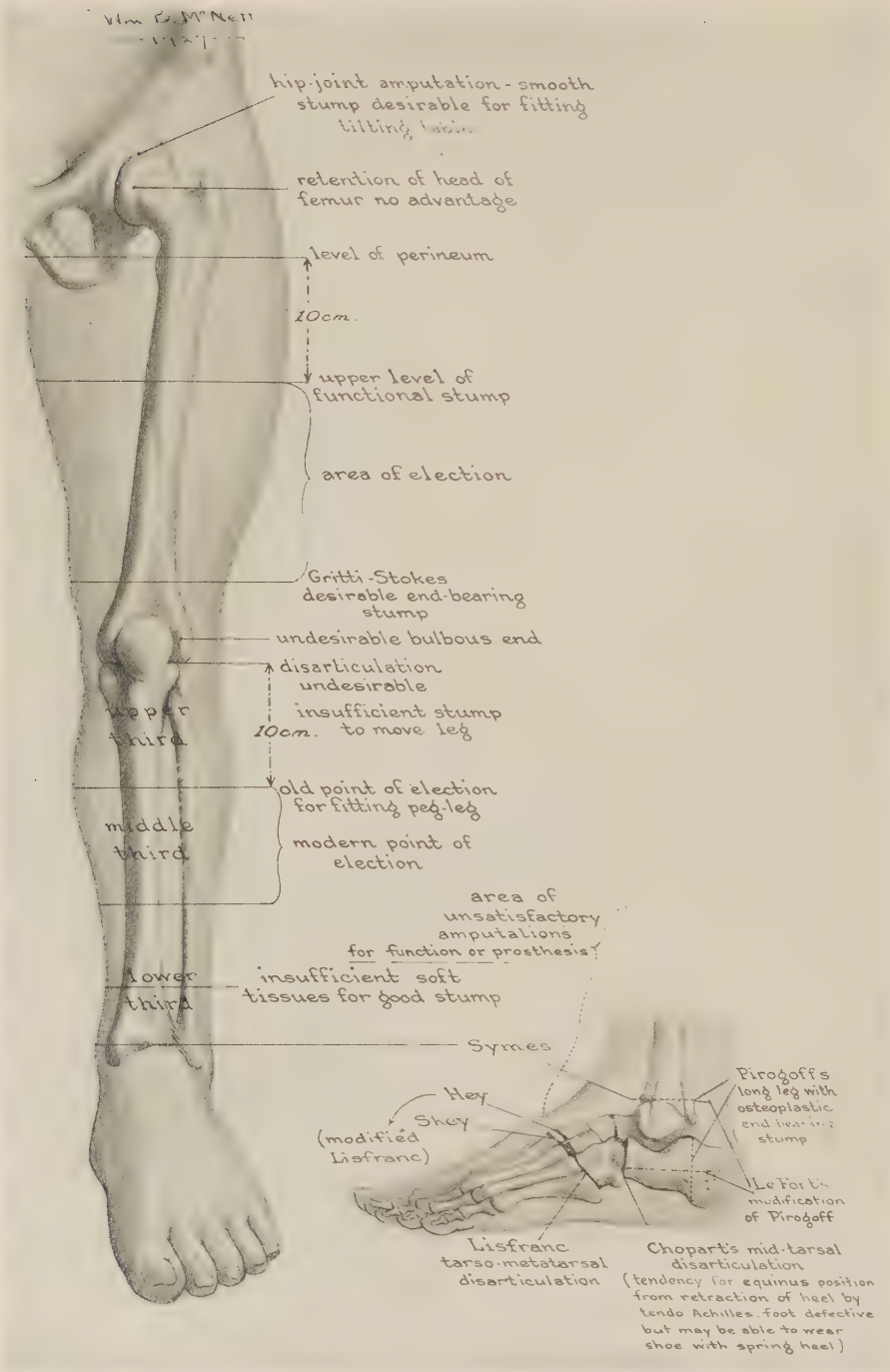

hip-joint amputation - smooth stump desirable for fitting tilting table
retention of head of femur no advantage
level of perineum
10cm.
upper level of functional stump
area of election
Gritti-Stokes desirable end-bearing stump
undesirable bulbous end
disarticulation undesirable
insufficient stump to move leg
10cm.
upper third
old point of election for fitting peg-leg
middle third
modern point of election
area of unsatisfactory amputations for function or prosthesis
lower third
insufficient soft tissues for good stump
Symes
Hey
Shey (modified Lisfranc)
Pirogoff's long leg with osteoplastic end bearing stump
Le Fort's modification of Pirogoff
Lisfranc tarso-metatarsal disarticulation
Chopart's mid-tarsal disarticulation (tendency for equinus position from retraction of heel by tendo Achilles. foot defective but may be able to wear shoe with spring heel)

Fig. 486.—Amputations of the leg and foot in relation to function.

the associated metatarsal bone, the handle of the racket is extended to a point slightly above the tarsometatarsal joint. Portions of the metatarsals should

be saved if feasible. Amputation of the small toe causes little disability, of the great toe, moderate disability.

Amputation Through the Foot.—The long flap should, if feasible, be obtained from the sole, care being taken to preserve as great a length of the foot as possible to prevent secondary equinus position from contraction of the tendo calcaneus.

Amputation through the metatarsus may be performed at any level by dorsal and plantar flaps or by an elliptic incision; as much bone as possible should be conserved, and the tarsometatarsal articulation should be retained. The scar should be dorsal. Removal of two intermediate metatarsals causes little disability, but amputation of three metatarsals may seriously interfere with walking.

Tarsometatarsal (Lisfranc's) Amputation.—Dorsal Flap: A curved incision is made from the base of the first to the base of the fifth metatarsal crossing the middle of the metatarsal bones. *Plantar Flap:* The incision begins proximal to the base of the fifth metatarsal, passes along the lateral edge of the foot, curves across the sole under the necks of the metatarsal bones, to turn along the medial aspect of the foot to the metatarsocuneiform joint. The knife is inserted behind the base of the fifth metatarsal, and the three lateral metatarsals separated from the cuboid and third cuneiform. The base of the first metatarsal is then separated from the first cuneiform. The base of the second metatarsal (wedged between the three cuneiforms) is separated by entering the knife between the second metatarsal and first cuneiform, dividing the interosseous ligament, then depressing the foot, dividing the dorsal ligament, and completing the disarticulation. To avoid this difficulty in disarticulating, the projecting part of the first cuneiform (Hey's method) or the base of the second metatarsal (Skey's method) is sawn through. Condon disarticulates the first metatarsal, and saws the remaining bones at the same level. In the Lisfranc amputation it is desirable to suture the chief tendons, as the tibialis anterior and posterior, and the peronæi tendons to the stump, to preserve the muscular balance and to prevent deformity from contraction of the posterior muscles. After this operation, the projection of the first cuneiform and cuboid may cause a painful stump. The Lisfranc amputation gives an end-bearing stump, with insufficient anterior support and inability to wear an ordinary shoe. Many surgeons consider an amputation through the leg preferable.

Midtarsal (Chopart's) Amputation.—The incision begins on the medial side of the tubercle of the navicular, curves forward over the sole of the foot to 2 cm. proximal to the heads of the metatarsal bones, and terminates at a point midway between the lateral malleolus and the base of the fifth metatarsal. A short, curved dorsal flap is made, the talonavicular and calcaneocuboid articulations are opened from the dorsal side. The muscles and tendons of the flaps should be sutured together, especially the tibialis anterior to the extensor tendons. There is a marked tendency for the heel to be pulled up, so that the patient walks upon the end of the astragalus. *Forbe's modification* consists in separating the cuneiform bones from the navicular, and sawing through the cuboid. Chopart's amputation is the worst amputation in front of

the ankle, from lack of muscle-balance and the tendency to increasing equinus and some varus. Prosthesis is difficult, and amputation through the leg is preferable.

Subtalar Amputation.—A racket-shaped incision is started at the insertion of the tendo calcaneus, extending along the lateral side of the foot, to a point just proximal to the base of the fifth metatarsal where it diverges and encircles the foot. The margin of the incision is reflected, the tendo calcaneus divided, the talonavicular joint opened as the foot is turned medially, the navicular separated from the calcaneus, and the foot removed. This gives a useful weight-bearing stump, covered by the skin from the heel; not well adapted, however, for the fitting of an artificial foot.

Ankle-joint.—*Disarticulation with Removal of the Malleoli and the Articular Surface of the Tibia (Syme's Amputation).*—From the tip of the lateral malleolus the incision is carried under the heel, to a point 15 mm. below and behind the medial malleolus. The flap is dissected from the calcaneus, hugging the bone to preserve the calcaneal vessels; a dorsal incision, slightly convex anteriorly, unites the ends of the first incision. The ankle-joint is opened anteriorly, the posterior ligaments and tendo calcaneus divided, the distal end of the tibia and fibula sawn off. The posterior tibial and the terminal branches of the peroneal vessels should carefully be preserved, and periosteum removed from the lower ends of the bones. The anterior tendons are sutured to the calcaneus tendon, or the periosteum of the tibia.

Syme's amputation gives a good end-bearing stump with good stability and gait, but is difficult to fit with an artificial foot without a wide, unsightly ankle.

Pirogoff's amputation is an osteoplastic amputation, in which the posterior portion of the calcaneus is sawn off and approximated to the sawn ends of the tibia and fibula. The skin incisions resemble those of Syme, the plantar incision forms a right angle with the dorsal, being carried obliquely forward instead of vertically downward. The distal ends of the tibia and fibula are sawn obliquely, and almost parallel with the sawn surface of the calcaneus. The sawn surfaces of bone are held in apposition by wire or catgut sutures. *LeFort's modification* consists in sawing the tibia and calcaneus horizontally. In *Ferguson's modification* the malleoli are not removed, and the fragment of calcaneus is mortised between.

The Pirogoff amputation is unsatisfactory because it is difficult to obtain a solid bony union in a good position, or to fit an artificial foot, the stump being too long for the adaptation of an ankle-joint.

Comment.—Amputations of the foot leaving but a single toe (even the great toe) are undesirable. The metatarsal heads should be retained, if possible, to support the anterior arch of the foot. A fairly satisfactory foot results from amputation through the metatarsals, distal to the attachment of the tibiales and peronæi; but most of the amputations through the tarsus are followed by retraction and equinus position, which interferes with walking and often necessitates a secondary amputation. This, coupled with the difficulty in fitting tarsal amputations, has caused many surgeons to routinely amputate through the leg in preference to amputating through the tarsus or ankle. Syme's amputation gives a satisfactory end-bearing stump in about 85 per cent. of the cases.

It is preferable to the Pirogoff amputation, which elongates the leg and is difficult to fit with an artificial foot.

Leg Amputations.—The *old point of election* in amputating through the leg, 10 cm. (4 inches) below the knee, was that used for fitting a peg-leg which is worn with the knee flexed. Amputations through the lower third of the leg are unsatisfactory, the tibia being small, the soft tissues scanty, the skin thin, the stump tending to become atrophic, tender, cyanotic, and to ulcerate. For the proper fitting of an artificial leg, the leg should be amputated between a point 20 cm. above the ground and 10 cm. below the lower edge of the patella. The middle third is preferred to the upper third of the leg. A stump shorter than 8 cm. cannot be satisfactorily fitted, and an amputation above the knee is to be preferred. A three-tailed cloth retractor is used, a fascial flap formed to cover the muscles, the fibula should be divided at a higher level than the tibia, and the sharp anterior edge of

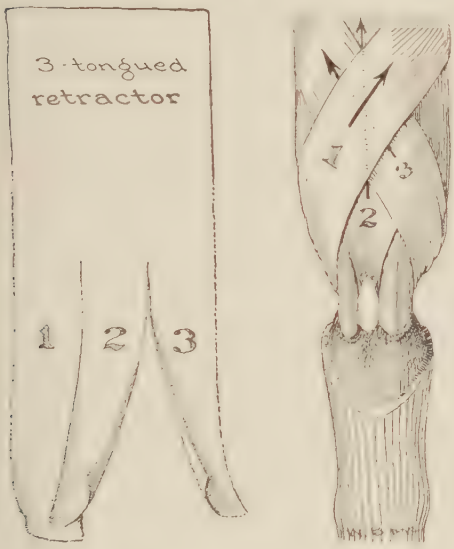


Fig. 487.—Three-tailed retractor used in holding the soft tissues out of the way while sawing the bones. A two-tailed retractor is used where a single bone is to be divided.

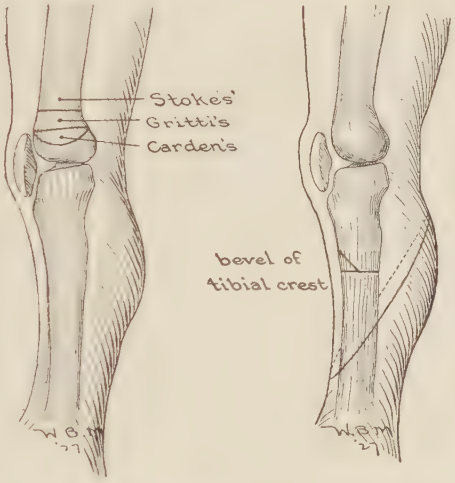


Fig. 488.—Oval amputations through the leg, with contouring of sharp tibial crest.

the latter should be beveled by an initial saw cut. Lateral flaps of equal length, or a modified circular amputation, is useful.

Teale's method consists of two rectangular flaps including all structures down to the bone; the length and the breadth of the long flap is equal to one-half the circumference of the leg at the point of amputation. The short flap is one-quarter the length of the long flap. The length of the long flap may necessitate an undesirable sacrifice of bone, and the method can rarely be used with satisfaction.

After amputation through the leg, a pressure bunion may form over the end of the fibula, or a neuritis occur from pressure by the edges of the stump socket upon the common peroneal nerve, as it winds around the neck of the fibula.

Stephen Smith's disarticulation of the knee-joint is objectionable on account of the bulbous end of the stump, the articular cartilage which may continue

to secrete synovial fluid, and the tendency of the skin over the condyles to become stretched, thin, and ulcerated.

Supracondyloid amputation (Carden's method) is made with a long anterior and a short posterior flap, the incision passing from one condyle to the other. Anteriorly it extends 5 cm. below the patella. The condyles are divided just below the epiphyseal line, and the sharp edges rounded.

Gritti-Stokes amputation is an osteoplastic amputation using the sawn patella to cover the lower end of the femur, and employing a long anterior and short posterior flap. The anterior incision extends from the condyles of the femur to the tuberosity of the tibia, and retains the patella. The posterior short flap is made by a curved incision connecting the ends of the anterior. The femur is divided just above the condyles, the posterior surface of the patella removed by a fine saw, and the patella sutured to the sawn surface of the femur

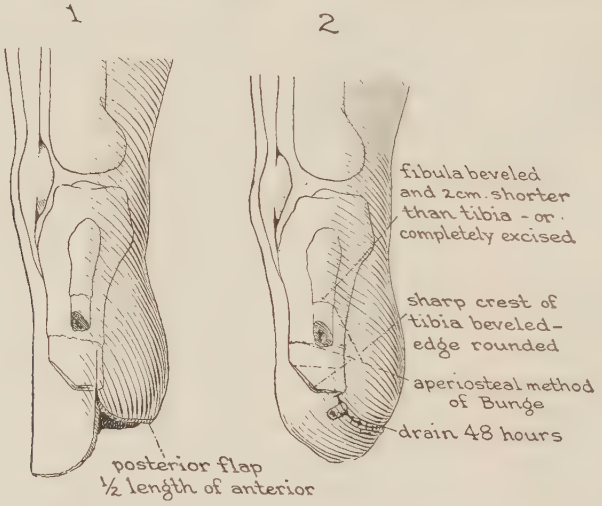

1
2
fibula beveled and 2cm. shorter than tibia - or completely excised
sharp crest of tibia beveled - edge rounded
periosteal method of Bunge
drain 48 hours
posterior flap ½ length of anterior

Fig. 489.—Amputation of the leg with long anterior and short posterior flaps. The tibia and fibula are beveled.

with catgut. The patellar tendon is divided near its insertion, the hamstring muscles are cut at their insertions and preserved, the patella turned back, its articular surface sawn off, all synovial membrane being removed. *Above the patella* the tendon of the quadriceps may be divided to prevent the strong pull of the muscle during healing. The gracilis, sartorius, semitendinosus, and semimembranosus, with the biceps of the lateral side, are sutured to the ligamentum patellæ, to balance the pull of the quadriceps. End-bearing may be begun with a provisional limb in six to eight weeks.

A Gritti-Stokes has advantages over the more distal Carden amputation, as it gives end-bearing without adhesions between the bone and the skin.

Amputation Through the Thigh.—Circular, oval, or long anterior and short posterior flaps may be used. The thigh stump should be at least 12 cm. long, measured from the crotch. The muscles are divided about 8 cm. distal to the point of division of the bone. For amputations proximal to the midthigh a pelvic band is necessary to hold the artificial leg.

Disarticulation at the Hip-joint.—The incisions used include the long anterior and posterior flaps of Furneaux Jordan, the anterior racket incision of Larrey, and Kocher's oblique incision preceded by a preliminary dislocation of the hips. The enucleation type of amputation is applicable to the hip, and especially with the anterior racket incision of Larrey enables the operator to ligate the femoral vessels as the first step of the operation.

Fig. 490.—Furneaux Jordan's disarticulation of the hip, showing the large amount of tissue of the thigh retained.

Fig. 491.—Kocher's hip-joint amputation with preliminary dislocation of the head of the femur through a resection incision. Circular skin incision below. The lymphoid tissue of the groin is not accessible and a large part of the upper thigh is retained.

Fig. 492.—Keen's incision for the interilio-abdominal amputation: Anterior incisions.

Fig. 493.—Keen's incision for the interilio-abdominal amputation: Posterior incisions. The flap is formed chiefly from the upper medial third of the thigh.

Interilio-abdominal Amputation (Babcock's Method).—The first incision begins 4 cm. above the pubis, curves upward to a point almost 8 cm. above the middle of Poupart's ligament, and ends about 4 cm. above the anterior superior spine of the ilium. If there is inguinal enlargement or infiltration of the skin of the inguinal region, the first incision is modified so as to be well above the infiltrated area. Lifting the upper skin edge the fat is undercut, so as to insure its removal to a level several centimeters above the skin incision, where the incision is deepened to the aponeurosis. The external oblique and the fat and fascia are dissected down to a point about 6 cm. above Poupart's ligament, where the incision divides the muscles to the peritoneum. The superficial and inferior epigastric and superficial and deep circumflex iliac arteries are tied and divided. The peritoneum is now separated from the hollow of the ilium to a line well above the brim of the pelvis, near the bifurcation of the aorta; any portions of infiltrated peritoneum are resected, and the opening at once closed. As a rule, the peritoneum is not opened. With adjacent malignancy, the operation is rendered more thorough by a high ligation and division of the spermatic vessels and cord, with castration in men, or a high division of the round ligament in women. The femoral nerve is injected with a 2 per cent. solution of procain, and divided. Beginning as near the bifurcation of the aorta as possible, the areolar lymphoid tissue is separated from the vessels and the pelvis. The external iliac artery is now doubly ligated and divided just below the bifurcation of the common iliac, and a provisional non-traumatizing clamp placed upon the hypogastric artery. After elevating the leg for a moment to conserve the contained blood, the external iliac vein is ligated and divided.

Fig. 494. — Babcock's interilio-abdominal amputation for malignant disease or infection. None of the thigh tissue is retained, and all of the inguinal lymphatics together with a part of the lower abdominal wall are removed *en masse*.

The operation should be nearly bloodless. From the outer end of the first incision, a second incision is carried down to the great trochanter, the iliopsoas muscle divided fairly high, its sheath freely removed and stripped down, hugging the bone, until the attachments of the inguinal ligament are divided and the acetabulum entered. With the thigh hanging over the edge of the table, disarticulation is readily produced and the incision continued, exposing the great sciatic nerve; this is blocked by procain, and divided as high as can conveniently be done. From the end of the second incision, the skin is divided along, or above and parallel with the gluteal fold; it is curved anterior when it reaches a point lateral to the perineum, to join the pubic end of the first incision. The gluteal and other muscles are divided, parallel with and about 1 cm. above the posterior skin incision, completing the amputation. The iliac bone protrudes through the incision. According to the degree of involve-

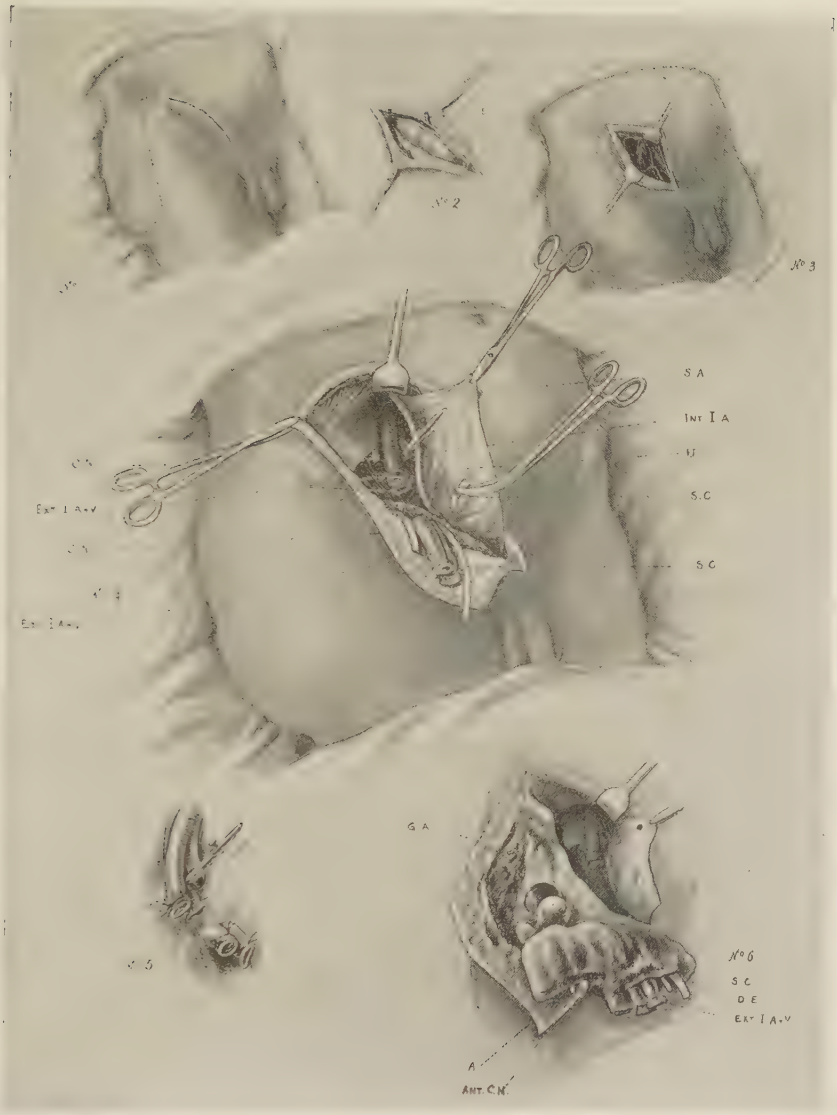


Fig. 495.—Babcock's interilio-abdominal amputation: No. 1. First incision. Second incision indicated by dotted line. No. 2. Primary incision deepened well above inguinal lymph-nodes, the superficial vessels and inferior epigastric artery, *E*, being secured and divided. No. 3. The peritoneum is exposed; the femoral nerve infiltrated and divided. No. 4. The peritoneum is retracted, exposing the pelvis and the iliac bifurcation. Just below the bifurcation, the external iliac vessels are doubly ligated and divided, and a provisional clamp placed on the hypogastric artery, thus controlling the circulation. The iliopsoas is divided high, and the distal portion with adjacent areolar and lymphoid tissue stripped down *en masse*, cleaning the iliac fossa and the lateral aspect of the pelvis to the bone. *C. N.*, Anterior crural (femoral) nerve; *S. A.*, spermatic vessels; *Ext. I. A. & V.*, external iliac artery and vein; *U*, ureter; *S. C.*, spermatic cord. No. 5. Detail showing the clamp on hypogastric artery and the divided external iliac vessels. No. 6. The skin flap is partially formed by the second incision, and the soft tissues including ligament separated from the bone. The acetabular cavity is opened and the head of the femur disarticulated. *G. A.*, Gluteal artery; *Ant. C. N.*, femoral nerve; *Ext. I. A. & V.*, external iliac artery and vein; *D. E.*, inferor epigastric artery; *S. C.*, spermatic cord.

ment, the bone is resected or disarticulated. Resection, by sawing off the distal part of the innominate bone with an ordinary amputating saw, is much simpler

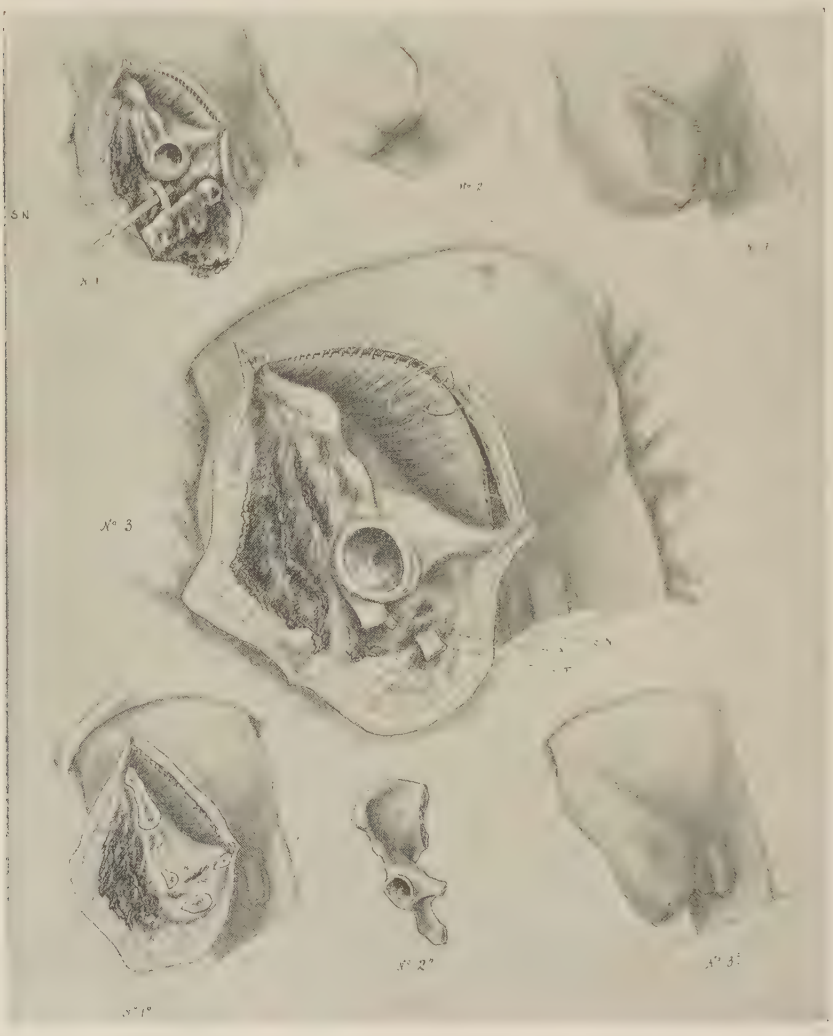


Fig. 496.—No. 1. The skin flap is completed and the deep tissues of the buttock divided after exposing and infiltrating the sciatic nerve which soon comes into view after the disarticulation. *S. N.*, Sciatic nerve. No. 2. Showing line of posterior skin incision; this is made somewhat higher when the innominate bone is removed. No. 3. Amputation completed. The stump of the iliopsoas is sutured to the edge of the internal oblique and transversalis, forming a new and higher abdominal floor. *S. N.*, Sciatic nerve; *A*, sciatic artery; *T*, tendon of hamstrings. No. 4. Musculocutaneous flap sutured, showing the relatively short incision. The edge of the gluteal muscles is sutured to the edge of the external oblique, reinforcing the abdominal wall. Drainage is secured by a small tube from the pelvis through a stab wound in the dependent portion of the flap. No. 1^b. Partial innominate resection. This is readily carried out with an ordinary amputation saw. No. 2^b. Portion of bone removed. No. 3^b. Completed stump after innominate resection.

and safer. If a disarticulation is necessary, the symphysis is divided by a knife, or the pubis by a saw, the bone rotated outward and the sacro-iliac ligaments

divided from within outward. The divided gluteal, sciatic, and pubic vessels are now tied; the clamp removed from the hypogastric artery; the stump of the divided iliopsoas mobilized, brought forward, and united with the edge of the internal oblique and transversalis; a drainage-tube is carried through the gluteal flap into the pelvis, and the divided edge of the gluteal muscles and the covering aponeurosis sutured to the external oblique, reinforcing the abdominal wall. The skin-flap is finally brought forward and the wound closed. The operation is readily performed under local or sacral anesthesia, the anesthetization being started as for herniorrhaphy, and continued by the infiltration of the femoral and sciatic nerves. The operation has the advantage of leaving a relatively small skin incision, and in removing the deep and superficial inguinal glands *en masse*. From five such amputations there were two deaths.

Fig. 497.—Stump after interilio-abdominal amputation with resection of the innominate bone.

Comment.—Amputations *through the lower third* of the leg are objectionable from lack of soft tissues, smallness of the tibia (insufficient for end bearing), and, in many cases, imperfect circulation; *through the thigh* the best amputation is through the base of the condyles, although certain instrument makers consider the retention of the denuded condyles, with the patella affixed, of use in holding the artificial leg. The thigh stump should be at least 9 cm. long, to swing the artificial leg.

A stump shorter than 9 cm. from the lower trochanter is unsatisfactory for fitting, and should be avoided. Above the level of the small trochanter it is possible to fit an artificial limb, with intervention of a hip platform or *tilting table*. The femoral head, or great trochanter, does not prevent the fitting of an artificial leg, but amputations through the great trochanter, femoral neck, or disarticulations are preferable.

Part IV

REGIONAL SURGERY

CHAPTER XXXII

THE SCALP AND SKULL

Congenital Injuries. 1. *Injuries of the head in utero* are unusual. Necrosis from pressure of the head against the sacral promontory, contusions, and, in very exceptional cases, fracture may occur from force transmitted through the maternal parts.

2. *During Labor:* Erythema, excoriations, ecchymosis, necrosis, and sloughing of the skin or cornea occur from the pressure of forceps, the promontory of the sacrum or, in a flat pelvis, the pubis. Paralysis of the facial nerve follows the pressure of forceps, but usually disappears within a few days after birth.

Caput succedaneum is a circumscribed edema with transudate, exudate, or ecchymosis, occurring over the presenting part of the head, and limited by the ring of the dilated os (when the area is round); or by pressure of the pelvic floor (when the area is oval). No special treatment is required, even the largest disappearing within three days after delivery.

Cephalhematoma, an extravasation of blood between the pericranium and one of the cranial bones, is usually parietal, but may occur over the frontal or occipital bone. It is produced by the same causes as lead to caput succedaneum, and occasionally by a fissured fracture. The swelling often increases the first few days after birth, and the blood may remain fluid for as long as four weeks. After two weeks, a ring of forming bone may develop at the periphery, and extend toward the center. Early absorption, formation of a flat bony boss or ridge of bone around the effusion may follow; or, in rare cases, suppuration, necrosis of bone, and meningitis. Cephalhematoma is distinguished from a cephalocele by the site, limitation to a single bone, and the absence of a fontanel under the area.

Treatment: (1) Await spontaneous absorption. (2) Puncture or aspiration followed by pressure, if the effusion is increasing or persistent. (3) Incision and drainage should be employed only if suppuration develops.

Deformation of the skull during labor is normal, the occipital and frontal bones sliding under the parietal, and the head being molded and changed in shape during delivery. Within twenty-four to forty-eight hours the bones return to position, but several weeks pass before the altered contour of the head is fully corrected.

Individual bones may show: (*a*) *Flattening;* (*b*) *shallow, gutter-like depressions,* especially along the coronary border of the parietal bone; (*c*) *deep oval* or *boat-shaped depressions* from instrumental delivery, the pressure of the promontory of the sacrum or, rarely, an ankylosed coccyx.

Prognosis in type *a* is good; in *b* it is fair, the condition often being overlooked until the child is two or three days old. In type *c* 50 per cent. are free from symptoms, 30 per cent. stillborn, while 20 per cent. die soon after birth, unless promptly given operative relief.

Treatment for types *b* and *c:* Craniotomy and elevation of the deformed bone, using local anesthesia with ½ per cent. procain solution.

For medicolegal purposes it is important to distinguish the injuries which occur during from those that occur before birth. The history, the relative size of the child's head to that of the pelvis, the duration of labor, and the amount of accouchement forcé are important deciding factors.

Congenital fractures usually involve the *parietal bone*, extending: (1) From the sagittal suture to the center of ossification with sharp smooth edges; or (2) parallel to the sagittal suture, with irregular serrated edges as the line of fracture crosses the rays of ossification.

Separation of sutures (*sagittal*, *coronal*, or *lambdoidal*) occur along the line of articulation, and may be complicated by rupture of blood-vessels or of sinuses, with death from hemorrhage or cerebral compression. A sinus also may be torn without injury to the articular membrane. In delivery of the after-coming head, separation of the lateral parts from the squama of the occipital bone may be fatal from hemorrhage or injury to the medulla.

Congenital Defects in the Skull.—Abnormal openings or fissures found in the skull of a newborn child are characterized by symmetrical distribution, gradual thinning of the edges when observed by transmitted light, absence of hemorrhage and ecchymosis, and presence of firm adhesions between the periosteum and the dura under the defect, as opposed to the separation present in a true fracture.

Incomplete ossification is readily distinguished from fracture, the bone being soft, easily indented, and containing numerous island-like fragments of bone, while defects in ossification may be found in other parts of the body.

The newborn child with cranial injuries may cry vigorously at first, then fail to nurse, develop stupor and convulsions, and finally, if unrelieved by operation, die.

THE SCALP

Subcutaneous Injuries.—The scalp is thick, dense and vascular, and contusion results in the rupture of blood-vessels and the extravasation of blood into the tissues, with the formation of a firm hematoma or hematocele. The effusion may be subcutaneous, subaponeurotic, or subpericranial.

1. **Subcutaneous.**—The blood effused into the tissues of the scalp forms a firm swelling, at times with raised margins, closely resembling a depressed fracture; the surrounding ridge, however, (a) is above the general level of the skull; (b) is compressible on firm persistent pressure, and (c) may be felt underneath the intact skull. Where there is a depressed fracture there is an irregular edge of bone, and the depression is below the level of the rest of the skull.

2. **Subaponeurotic hematoma** occurs under the occipitofrontalis, the effusion spreading from the frontal eminence to the occipital ridge. The blood may gravitate with the position of the patient, to the eyebrows, zygoma, or occiput; and may pulsate when a large artery has been torn.

The *treatment* is a firm bandage with elastic pressure. If the effusion is large and persistent, or if a residual cyst remains, the blood and serum should be aspirated through a large needle.

3. **Subpericranial effusions** are seen chiefly as the cephalhematoma of the newborn, and are limited to a single bone.

Wounds of the scalp may be incised, lacerated, or contused. A fall upon a flat pavement, or a blow from a club, often produces a linear wound resembling an incision by a sharp instrument, the scalp splitting or rupturing under compression, or being incised by an underlying bony ridge of the skull. The wounds do not gape unless the aponeurosis is widely divided. The hemorrhage is profuse, as the vessels of the scalp cannot well contract or retract. The great danger is infection, which may spread locally or along the emissary veins to the meninges and intracranial sinuses. The scalp has great vitality, withstanding traumatism, antiseptics, and tight sutures better than many other tissues. It is also more

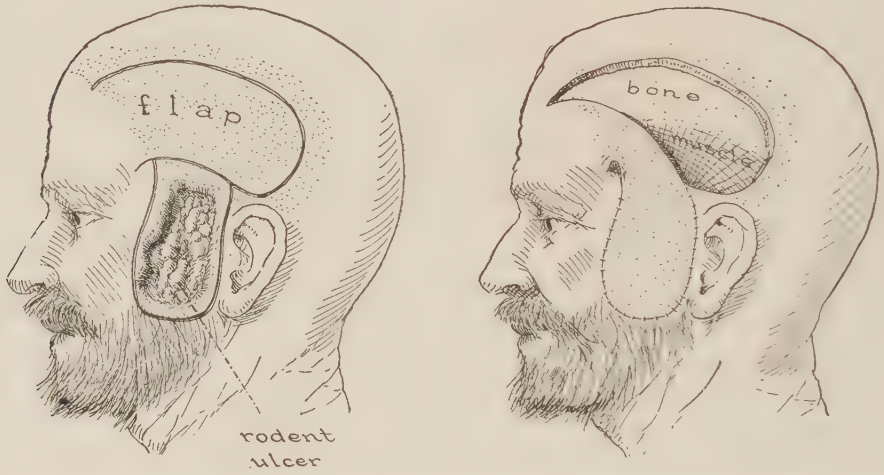


Fig. 498.—Correction of a defect in the face, after removal of a rodent ulcer, by a pedicled flap raised from the scalp.

resistant to infection. Sloughing is unusual, despite severe laceration and contusion.

The wound and adjacent scalp should be thoroughly cleansed with ether or turpentine, the scalp shaved, the parts thoroughly disinfected with 5 per cent. phenol, 1 : 1000 bichlorid of mercury, or $3\frac{1}{2}$ per cent. tincture of iodin; dirt-infiltrated tissues pared away, hemorrhage arrested, and the wound carefully closed without drainage. Primary union depends more on a careful technic than the amount of dirt present, and the patient whose scalp wound suppurates may well ask his surgeon "Why?" Secondary suture and drainage are to be avoided. If serum later forms under the scalp, it should be evacuated between sutures. The stitches may be removed from the third to the sixth day, and boric-acid ointment applied if there is tendency to scabbing about the hairs.

Avulsion of the scalp occurs chiefly in mill-girls whose long hair is caught by revolving belts. The entire scalp may be pulled from the skull.

Treatment.—If a small area of the scalp has been removed, it may be disinfected and sutured back in position. The completely avulsed scalp never reunites, but Thiersch's skin-grafts may be applied directly to the clean denuded skull, the outer layer of which is removed with a sharp chisel until bleeding points are observed. These grafts may unite almost as well as upon soft tissue, and it is not necessary to wait for the outer layers of the skull to exfoliate and granulations to form.

Traumatic cephalhydrocele occurs with fracture of the vault in children, the cerebrospinal fluid escaping through the fracture producing a localized swelling of the scalp, which may pulsate with the heart and respirations, and become tense on exertion. At times the underlying opening through the skull is palpable.

Treatment is compression, with or without aspiration. If cerebral symptoms are associated, the dural or cranial opening should be closed through an incision.

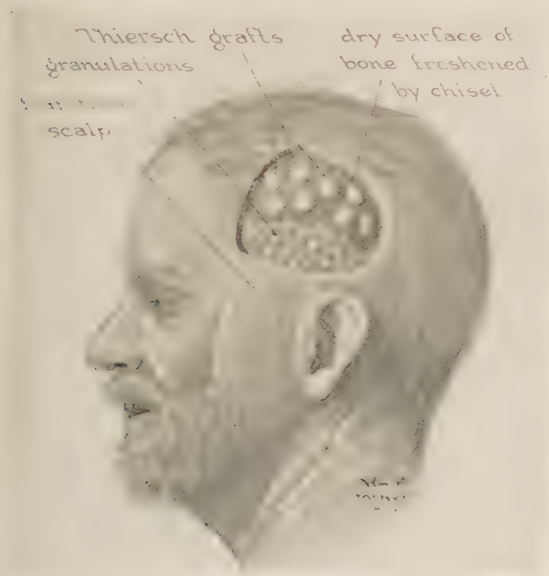


Fig. 499.—Correction of a defect in the face, after removal of a rodent ulcer: The base of the flap was divided at the end of ten days and returned to its former position. The denuded dry skull has been freshened by a sharp chisel and Thiersch grafts applied.

Fig. 500.—Result from Thiersch grafting upon the dry skull.

Pneumatocele results from the escape of air under or in the scalp, in fracture involving the nasal or mastoid sinuses. The swelling is characterized by emphysematous crackling, which is felt on pressure. The condition, as a rule, spontaneously disappears within two or three days, and requires no treatment except, possibly, elastic compression and a bandage.

Infections of the Scalp.—**Boils** and **carbuncles** are not infrequent upon the scalp, especially over the occiput. As the scalp is thick and inelastic, very painful tension is produced; liquefaction necrosis and evacuation are slow on account of the firmness and density of the tissues. The necrotic tissue finally is expelled as a sphacelus or core, the opening then closing by granulation.

Etiology.—Staphylococci, which enter the scalp through the hair-follicles or sebaceous glands. In the aged, diabetic, or asthenic the infection may be serious and even fatal.

Treatment.—Abortive: In the early stage of carbuncle or furuncle, when only an indurated papule or pustule is present, 2 minims of liquefied phenol are injected in the center of the mass by a fine hypodermic needle, and the area covered by yellow oxid-of-mercury ointment. If the condition has progressed beyond this stage, the furuncle should be incised to relieve tension and favor drainage. Carbuncles should be freely excised under nitrous oxid gas or ethylene. Excision shortens the period of disability, relieves the pain, and reduces the danger of septic absorption. The skin around boils and carbuncles should be disinfected frequently with alcohol, and kept coated with a mercurial ointment to prevent secondary infection.

Pustulation and *furunculosis* of the scalp in infants and young children may be very troublesome, especially if treated by ointments or occlusive dressings. The scalp should be washed once or twice daily with tincture of green soap, and kept exposed to the air without a dressing or bandage. An adjusted diet with sufficient vitamins, fresh air, and sunshine are important accessories.

Cellulitis of the scalp should be treated early by antiseptic fomentations or a 2 per cent. yellow oxid-of-mercury ointment. With the formation of pus, free incision and drainage should be used. For *erysipelas of the scalp*, cold compresses wet with a 2 per cent. solution of aluminum acetate are useful.

Subaponeurotic infections spread widely over the skull outside the pericranium, and are difficult to drain, as incisions made through the scalp tend to close. Sufficient dependent tube-drainage should be used, and a copious wet antiseptic dressing continuously applied.

Subpericranial infections require early incision and antiseptic dressings. The condition may result from a spreading infection in the frontal sinus, and give rise to a progressive osteomyelitis, and secondary meningeal or cerebral infection.

Pott's puffy tumor (Percival Pott, 1760) is an inflammatory swelling and edema of the scalp over an area of localized bone necrosis and meningitis. It develops a few days or several weeks after injury, usually in the alcoholic or debilitated. If the abscess is large, symptoms of cerebral pressure occur. It is serious because of the danger of secondary spreading meningitis.

Treatment is craniotomy and drainage.

Sebaceous cysts or **wens** frequently occur in the scalp, are often multiple and, especially after middle age, may undergo suppuration, ulceration, or epitheliomatous degeneration.

Treatment.—Enucleation under local anesthesia, taking care to remove all of the capsule to prevent recurrence.

Dermoid cysts develop at the anterior fontanel, at the occipital protuberance, or lateral angle of the orbit. An underlying defect in the bone may be present, the cyst connecting with the dura. They should be removed with great care under rigid aseptic precautions.

Serous cysts, possibly a meningocele separated from the interior of the skull, rather rarely occur at the occiput, and are to be treated by aspiration or excision.

Adenomas arise from sebaceous- or sweat-glands, are single or multiple, of a purplish color with thin glistening overlying skin, and tend to ulcerate and fungate. They may become epitheliomatous.

Treatment is excision.

Plexiform neuromas develop on branches of the fifth nerve. *Von Recklinghausen's disease*, *molluscum fibrosum*, and *pachydermatocele* are varieties often characterized by masses of wrinkled or pendulous pigmented skin.

Cirsoid aneurysm chiefly involves the scalp and temple, with dizziness, headache, and distressing rush and roar of arterial blood. Enormous tortuous arteries course over the scalp and temple.

Treatment consists of a two-stage operation, a flap of scalp containing the involved vessels being first raised, and the vessels ligated. The flap is replaced after obliteration has occurred.

Traumatic aneurysm of the superficial temporal artery from injury, or arteriovenous aneurysm, should be treated by ligation of the vascular branches and excision.

Sarcoma is rare as a primary tumor, but occurs secondary to primary growths of the skull, brain, and face.

THE SKULL

Anatomic and Physiologic Considerations.—The veins of the face and of the midline of the skull communicate with the sinuses within the skull, and may carry infection from the face or scalp through the skull, leading to septic sinus thrombosis. The sinuses are compensatory within certain limits. The vasomotor center in the floor of the fourth ventricle regulates the blood-pressure. An increase of intracranial pressure is followed by a compensatory rise of the general blood-pressure, which only falls when the pressure within the skull no longer stimulates but causes anemia of the centers in the medulla. The brain is largely liquid and, therefore, nearly incompressible. If the circulation within the brain stops for seven minutes, the pyramidal cells of the cortex die; after ten minutes, the cells of Purkinje die.

Classification of Skulls.—Form of the Skull: The *cephalic index* is the ratio of the length of the skull (taken as 100 units) to the breadth. The *altitudinal index* is the ratio of the length to the height of the skull. The accepted horizontal line passes through the upper edge of the external auditory meatus and the lower orbital margin.

Dolicocephalic, or long head, has a cephalic index less than 75.

Brachycephalic, or short head, has an index of more than 80.

Mesocephalic is the intermediate type, the index being more than 75 and less than 80.

Platycephalic, or flat head, has a ratio of breadth to height less than 70.

Orthocephalic, or straight head, has a ratio of between 70 and 75 (height-length ratio).

Hypsicephalic or *hypsocephalous* means having a high head or high vertex, with a breadth-height index of more than 75.

Pathologic types of skull include the *hydrocephalic*, dropsical or water-head; *cephalonic* or big head; *microcephalic* or small head; *sphenocephalic* or wedge-shaped head; *leptocephalic* or narrow head; *clinocephalic* or saddle-shaped head; *trigonocephalic* or triangular head; *oxycephalic* or pointed head; *platycephalic* or flat head; *trochocephalic* or round head; *plagiocephalic* or unsymmetric, oblique head.

Facial Profile.—The facial angle of Camper is the angle between a line on the level of the external auditory meatus and the floor of the nasal cavity, and a line touching the middle of the forehead and anterior portion of the alveolar process of the maxillæ. If the angle is 80 degrees or more the person is orthognathous; if between 80 and 65 degrees, prognathous.

Congenital Anomalies.—Cephalocele is the congenital protrusion of cranial contents through a defect in the skull. It occurs once in 4000 births. The mass varies in size from that of a small bean to a child's head. Internal hydrocephalus, adhesions of the membranes about the fourth ventricle, or other defects are not infrequently associated. The usual sites are: (1) The occipital region, above or below the occipital prominence; (2) the root of the nose; (3) the anterior inferior angle of the parietal bone (rare); (4) the line of the sagittal suture; (5) the base of the skull, the sac projecting into the pharynx, mouth or nose, where it may be mistaken and removed for a polyp.

Meningocele is a sac of protruding piarachnoid, covered by scalp or skin and filled with cerebrospinal fluid, communicating with the interior of the skull

Fig. 501.—Occipital meningocele.

through a defect in the skull and dura. It occurs most commonly in the occipital region, with an opening in the midline of the occipital bone, between or above the foramen magnum and the occipital protuberance. It forms a globular, tense, smooth, translucent compressible mass, covered by thin skin which may show dilated vessels.

It may be sessile or pedunculated, becoming tense and larger when the child cries or strains, and reducing on direct pressure, possibly with associated cerebral symptoms, such as slowing of the pulse, vomiting, convulsions, or loss of consciousness.

Small meningoceles often remain stationary or even disappear, the larger may progress to rupture with secondary meningitis. Eczema, excoriation, ulceration, or infection of the overlying skin may be followed by meningitis.

Encephalocele is a defect in which the sac contains a protruding portion of the brain. It is not common, and usually occurs in the frontal region at the

base of the nose, forming an elastic pulsatile tumor with a broad base of variable size.

Hydrencephalocele is a protruding portion of the brain containing a cavity, a part of one of the ventricles. It usually occurs in the occipital region, and frequently is of great size; is not translucent like a meningocele, as a rule does not pulsate, but may become distended as the child cries, and often is associated with such deformity of the brain that the child dies during delivery or soon after birth.

Diagnosis.—Cephaloceles are differentiated from dermoid cysts, nevi, cephalhydrocele, and cephalhematoma by the underlying opening of the skull (which may be felt or shown by the *x*-ray), the size, location, translucency, and pulsation. In case of doubt, the sac may be carefully explored by a fine hypodermic needle.

Treatment.—Meningoceles are treated by excising the sac, closing the opening in the piarachnoid and, if possible, the opening in the dura. A transplantation of bone, cartilage, or fascia may be used to fill the defect in the skull. With the larger encephaloceles, and especially the hydrencephaloceles, the protruding cerebral substance unless of small size cannot be returned within the skull, and must be excised if operation is done. If the child does not die of the operation a secondary progressive and fatal hydrocephalus usually follows. The old treatment of injecting *Morton's fluid* (consisting of iodin, 1 part; potassium iodid, 2 parts; and glycerin, 30 parts) into the sac is no longer used.

Ventricular cyst is a thinned-out process of brain underlying the scalp, containing an extension from the ventricular cavity.

Sinus pericranii consists of large veins under the scalp, extending from the cranial sinuses, usually found at the base of the nose, the mass enlarging on straining or crying.

The condition may be *treated* by pressure and support or, if large or progressive, by operative ligation of the veins close to the skull.

Dermoids of the skull are rather rare and occur chiefly at the frontozygomatic junction, forming firm, doughy, non-compressible, non-pulsatile masses that do not communicate with the brain. *Treatment* is by excision.

Fractures of the skull are divided into those involving: (A) *The vertex;* (B) *the base of the skull.*

A. **Fractures of the vertex** or convexity of the skull are divided into: (1) (a) *Simple* or *closed*, and (b) *open* or *compound* fractures; (2) (a) *depressed* and (b) *non-depressed;* (3) *comminuted* fractures and (4) *complicated* fractures. Fractures are also classified into:

(5) (a) *Linear fractures* may be simply *linear* or V-, Y-, M-, or W-shaped. Separation of a suture line occurs in children, but a fracture rarely follows a suture line for any considerable distance in adults.

(b) *Bending fractures* are those in which the bone curves in at the point of impact. They include: (1) *Pond fractures* which are round or oval, without a sharp depressed edge; (2) *gutter* or *grooved fractures* which have a sharp depressed edge, the bone being bent in at an acute angle (*indentation fracture*). Depressed fractures are often comminuted. In children the soft skull may be depressed without fracture.

(c) *Bursting fractures* are caused by the expansion between the poles of impact and resistance, and occur along the meridians joining the poles between

Fig. 502.—Long anteroposterior linear fracture of the vertex. (Roentgenogram by Dr. G. C. Bird.)

which the skull is compressed. It is an indirect fracture, occurring in the bulge rather than at the point of depression of the skull. Radiating fissures form,

Fig. 503.—Long anteroposterior linear fracture of skull. Recovery without operation. (Roentgenogram by Dr. G. C. Bird.)

usually running down the temporal fossa of the vault, into the middle fossa of the base, and across the sella turcica between the strong buttresses formed

by the external angular process of the frontal and the small wing of the sphenoid in front, and the petrous portion of the mastoid posteriorly.

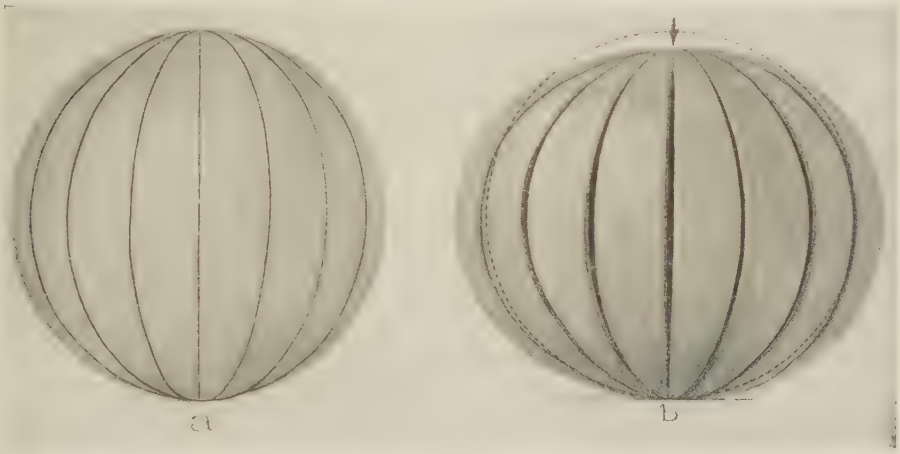


Fig. 504.—Mechanism in the production of bursting fractures of the skull. Compression of an elastic sphere (*a*) at the poles leads to separation at the meridians (*b*). Therefore, bursting fractures tend to run along lines joining the poles of compression.

(d) *Punctured fractures* of the skull occur from the entrance of a tack, nail, penknife, or other small pointed object. They are dangerous from the secondary meningitis that may follow.

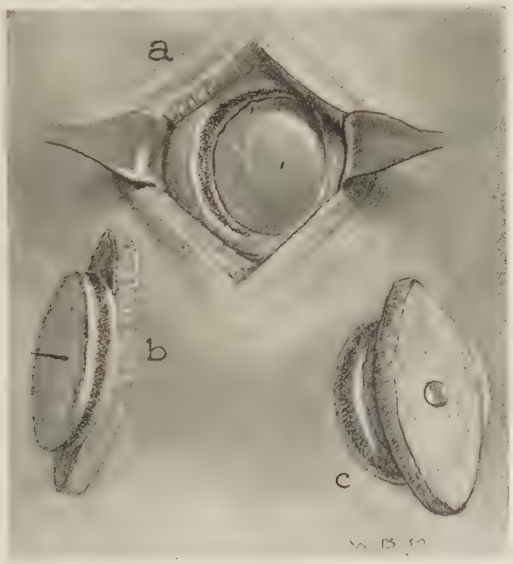


Fig. 505.—*a*, Puncture of the scalp, skull, dura, and brain of an infant from rolling on a small carpet tack; *b*, *c*, excised button of bone and scalp containing tack. Death from meningitis on the third day.

(e) *Fractures by contrecoup*, an erroneous term formerly applied in the belief that a fracture occurred at a point of the skull opposite that of the impact, from the transmission and focusing of the force around the walls of the skull.

Pathology.—The inner table usually is fractured over a wider area than the outer, because: (a) The inner table is unsupported from within; (b) the force diffuses as it passes from without inward; (c) the inner table is more brittle than the outer. In infants and the aged who have no diploë, the vault breaks as one piece. Occasionally only the inner table is fractured or, if a bullet strikes from within, the fracture may involve only the outer table of the skull.

At the time of production even of a simple linear fracture, the elastic bones often temporarily spring past each other, lacerating the dura and the vessels, especially the anterior or posterior branches of the middle meningeal artery lying in grooves on the inner surface of the skull. The intra- or extra-dural hemorrhage, which follows, causes cerebral compression. The brain may be

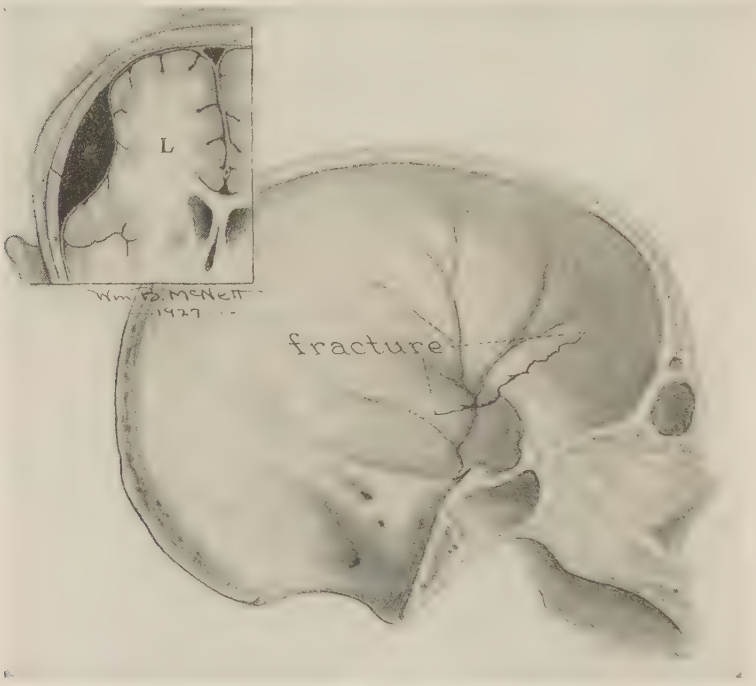


Fig. 506.—Fracture of the skull involving the anterior branch of the middle meningeal artery with secondary extradural hematoma showing compression of lobe of brain. *C*, Clot; *L*, compressed brain.

concussed, contused, or lacerated. A depressed fracture may press upon, irritate, or lacerate the brain. Fractures of the skull unite without palpable callus-formation. The regenerative power of the skull is very limited. Openings following injury exceeding 1 cm. in diameter are bridged by membrane, not bone.

Gunshot fractures may be associated with various types of injury to the skull. The energy of a missile is equal to one-half the mass, multiplied by the square of the velocity. Bullets of small caliber, with a jacket of hard metal such as steel or cupro-nickel and with an initial velocity of over 2000 feet per second, produce explosive effects at short range.

1. *At short range* the calvarium, scalp, and brain are blown to pieces, due to the entrance of the bullet at great speed into the semifluid and practically

incompressible brain which, not having sufficient time to be displaced, transmits the hydrodynamic force in all directions with a bursting effect upon the rigid walls of the skull. The brain may be carried several meters from the skull (*exenteratio cranii*).

2. *At 50 meters* the scalp is perforated, but the skull is comminuted. In warfare, these explosive effects have led to the false belief that dum-dum or explosive bullets were being used.

3. *At 100 meters* the skull shows areas of bending and bursting fracture about the points of entrance and exit, the area of entrance being small, and that of exit being up to 20 or 30 cm. in diameter.

4. *At 800* to *1300 meters* only radial fissures are found about the perforations.

5. *At 1800* to *2000 meters* there are drill effects or clean-cut, punched-out holes of entrance and exit.

6. *At 2000* to *2700 meters* the average skull is not perforated, but radial, depressed or comminuted fractures may be produced (von Bergmann).

Variations occur dependent upon the size, weight, and velocity of the bullet, and the thickness and strength of the skull. "Soft nose" bullets, the apex consisting of soft lead which mushrooms on impact, and "dum-dum" bullets, which have hollow soft points or the point of which contains a hollow chamber which bursts on impact, produce widespread comminution.

Tangent wounds (if the bullet strikes at a tangent) cause a grooved or circular fracture, often associated with bending. If linear or circular fracture occurs, the bullet may split, straddle the bone, or break into fragments.

Pistol or *revolver wounds*, except those from the high-velocity Luger automatic, even at short range cause few or no radial fractures, and the bullet rarely traverses a thick skull. One or two concentric fractures may be produced. The lesions therefore resemble those produced by spent bullets of initial high velocity. Similar wounds are also caused by shrapnel. The fragments of high-explosive shell may produce large defects in the skull and brain, the shell fragments, bone, and other foreign bodies being carried into the cerebral substance to be encapsulated and retained, to gravitate with secondary symptoms, or to produce spreading infection. In a few instances a large foreign body, as the minie ball, weighing 30 gm., has been retained in the brain for many years without symptoms.

Symptoms of the fracture alone are usually relatively slight and unimportant. Linear fractures are shown by exposing the bone or on the roentgenogram. There is no deformity, the overlying scalp may be edematous, and the delayed appearance of ecchymosis and emphysema is somewhat diagnostic. Depressed and comminuted fractures are recognized by change in the contour of the skull, and by the roentgenogram.

Cranial symptoms from fracture of the skull include those of: (1) *Cerebral concussion;* (2) *cerebral compression;* (3) *cerebral contusion* or *laceration;* (4) *meningitis, cerebritis, encephalitis,* or *cerebral abscess.* The movement of cerebrospinal fluid and the semifluid brain, caused by the blow, may cause injury to a part of the brain remote from the point of impact.

Diagnosis.—Depressed fractures of the skull are to be distinguished from: (1) Depression from parturition; (2) depressions from senile atrophy, the ab-

sorption occurring from without in, with shallow depressions or deep, sharply defined grooves; (3) depressions from syphilitic disease; (4) natural asymmetry due to peculiar cranial development; (5) from hematoma with raised edge and central depression. With fracture, the edge is sharp and not raised, the center is broken, depressed, and below the general bone level; while in hematoma the edges are somewhat compressible.

Prognosis.—(1) Simple fractures of the skull, without cerebral complications, have a mortality of 5 per cent.; (2) compound fractures of the skull, without penetration of the dura or cerebral complications, a mortality of 10 per cent.; (3) compound fractures of the skull, with penetration of piarachnoid but without serious cerebral injury, a mortality of 20 per cent.; (4) compound fractures of the skull, with contusion and laceration of the brain, a mortality of 40 per cent.; (5) gunshot wounds of the skull and brain, a mortality of 45 per cent., and (6) compound fractures of the skull with invasion of ventricles, a mortality of 90 per cent.

Treatment.—The treatment of closed fractures of the skull depends upon the associated intracranial injury. An uncomplicated simple fracture of the skull requires no special treatment. In all cases the patient should be placed in bed, and watched for the development of possible complications.

Depressed fractures, with or without symptoms, are treated by elevating the depressed bone. If an acute infection is present, bone should not be removed. In general the treatment for fracture of the skull is: (1) Arrest hemorrhage; (2) prevent infection by mechanical and chemical cleansing of any open wounds; (3) relieve pressure from depressed fractures, foreign bodies, or effused blood; (4) treat associated concussion, compression, or laceration of the brain; (5) close wounds and avoid drainage; (6) attend to secondary complications.

Compound fractures should be disinfected, débrided, and fragments and foreign bodies removed. The wound should be closed without drainage.

Gunshot fractures should be treated (Cushing) by: (1) Excision of the wound edges, using a Y-shaped incision, with removal of the contaminated edges of bone; (2) gentle irrigation with a fine soft rubber catheter and small glass funnel, with decinormal saline solution, to remove pulpified brain and blood-clots; (3) gentle probing with the catheter to detect and remove foreign bodies, such as detached fragments of bone, bullets, or other missiles; (4) arrest of hemorrhage; (5) filling of the defect in the brain with a 2 per cent. solution of dichloramin-T in chlorcosane; (6) closure of the overlying scalp without drainage.

B. **Fractures of the base of the skull** involve the (1) *anterior*, (2) *middle*, or (3) *posterior* fossa, and are usually transverse or obliquely transverse, with a tendency to cross the foramina at the base of the skull, and the petrous bone. They are dangerous from associated intracranial injury, and because basal fractures are frequently compound and followed by meningitis.

Etiology.—The base of the skull may be fractured by direct or indirect violence.

1. Direct Violence: The thin bony plate covering the orbit, nasal cavities, or pharynx may be punctured by a sharp stick, the end of an umbrella, fencing foil, a knitting needle, or similar object.

2. Indirect Violence: (a) *In operations within the nose* for deflected septum

or for drainage of the frontal or ethmoidal cells, fractures extending to the base of the anterior fossa or cribriform plate may be produced. (b) *In falls upon the vertex* or the side of the head, the after-coming body may fracture the base. Falls from a height upon the vertex may cause a *ring fracture* about the foramen magnum. Conversely, a fall upon the feet or buttocks may lead to fracture of the base by the inertia of the after-coming head. (c) *A blow upon the mandible* may fracture the base indirectly by the force transmitted through the mandibular (glenoid) fossa.

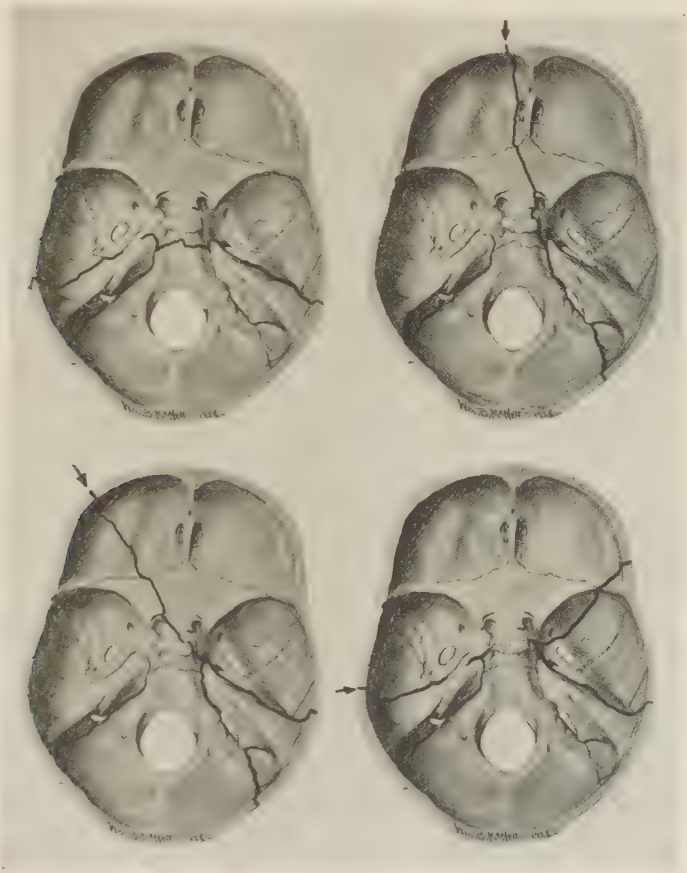


Fig. 507.—Fractures of the base of the skull involving the anterior, middle, and posterior fossa. Transverse fracture, anteroposterior fracture, oblique fracture of the base.

Most basal fractures are of the bursting type, and follow lines connecting the points between which the skull is compressed. If from side to side, the line of fracture tends to be transverse. If anteroposterior, the fracture line is longitudinal; if oblique, the line is diagonal. One or more fossa may be involved.

FRACTURES OF THE BASE ARE FREQUENTLY COMPOUND from: (1) The *anterior fossa* into the nose, pharynx, or nasal sinuses; (2) the *middle fossa* into the middle ear; and (3) the *posterior fossa* into the ear or, rarely, the posterior pharynx.

Symptoms.—1. SWELLING: A boggy swelling of the scalp over the fracture usually appears early.

2. Ecchymosis occurs after hours or days as blood from the area of fracture reaches the surface, and may have a characteristic location. (a) *Orbit.*—In fracture the ecchymosis is delayed and limited by the orbital margins. It involves the bulbar conjunctiva, later the eyelids and subcutaneous tissues, and is without associated evidence of contusion. The ordinary "black eye" develops promptly, involves the subcutaneous tissues, is associated with swelling and other evidences of bruising, and the ecchymosis spreads outside the orbit, particularly about the point of impact, usually over the malar bone, the infra-orbital or supra-orbital margin. An effusion of blood from within the orbit is limited by the tarso-orbital

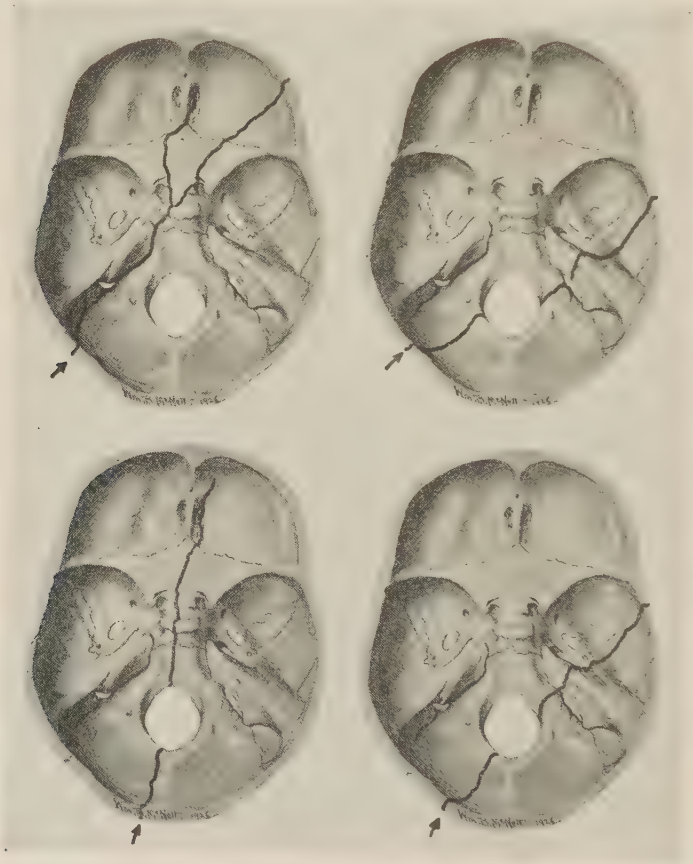


Fig. 508. –Types of anteroposterior and oblique fractures of the base of the skull.

fascia, which extends from the supra-orbital and infra-orbital ridges to the corresponding tarsal edges, and forms a partition separating the skin and subcutaneous tissues of the lid from those of the bulbar conjunctiva.

(b) *Pharynx.*—Ecchymosis of the mucous membrane of the pharynx occurs from fracture of the basilar portion of the occipital bone. The dense connective tissue of the upper nasopharynx prevents wide diffusion of the blood.

(c) *Mastoid.*—Ecchymosis over the lower or posterior part of the mastoid process (*Battle's sign*) appears several days after a fracture of the mastoid or of adjacent bone.

3. Hemorrhage from the nose, ear, or pharynx frequently accompanies fracture of the base of the skull, but is not pathognomonic.

4. Escape of cerebrospinal fluid from the nose, ear, and pharynx indicates a basilar fracture and an associated laceration of the dura. The patient may notice the salty taste from cerebrospinal fluid entering the nose or pharynx. From a few drops to 150 to 200 c.c. of cerebrospinal fluid escapes every twenty-four hours. The fluid is alkaline, contains sodium chlorid but no albumin, and reacts for glucose. Cerebrospinal fluid may enter the middle ear through the fracture or along the eighth nerve (Miles), and escape through the eustachian tube into the nose. Brain tissue may enter the nose, pharynx or middle ear in very severe fractures of the base.

5. Emphysema gives crepitation on palpation. The air enters the subcutaneous tissue of the eyelid, forehead, or malar region through fractures into the frontal or ethmoid sinuses.

6. Cerebral (Cranial) Nerve Lesions.—In order of frequency, the cerebral nerves are involved as follows: Seventh, eighth, third, fourth, sixth, second, first, ninth, tenth, eleventh, twelfth. The *seventh* or *facial nerve* is most frequently affected, producing facial or Bell's palsy. Injury of the *eighth* or *acoustic nerve* causes tinnitus, hyperacusis, deafness, or alterations in taste (*chorda tympani*); of the *third*, *fourth*, and *sixth* nerves, ocular palsies; of the *second* nerve, blindness or hemianopsia; of the *first* nerve, anosmia; of the *ninth* or *glossopharyngeal*, glossopharyngeal palsy; of the *eleventh* or *accessory* nerve, shoulder drop; of the *twelfth* or *hypoglossal* nerve, hemiparalysis of the tongue, which is protruded toward the affected side; of the *tenth*, tachycardia or (if stimulated) bradycardia.

Nerve symptoms are: (1) *Immediate*—when the nerve is injured at the time of the accident. (2) *Intermediate*—after several days from secondary edema or inflammation. (3) *Late*—after several weeks from secondary pressure, fibrosis, or meningitis.

Fractures of the anterior fossa may result from a fall upon the face or frontal bone, from an endonasal operation, or punctured wounds of the orbit or nasal cavity. From fractures of the vault, fissures may extend to the orbital plate, the frontal bone, or small wing of the sphenoid.

Symptoms.—Delayed ecchymosis of the orbit, first noted as a subconjunctival effusion, spreading from behind forward and from laterad and below, mesad and upward; finally involving the upper eyelid. With the dura and arachnoid divided, there may be escape of blood and cerebrospinal fluid or cerebral substance into the nose or pharynx. The first, second, third, fourth, or the ophthalmic divisions of the fifth and the sixth nerves may be damaged.

Fractures of the middle fossa usually follow falls or blows upon the vertex. The symptoms are escape of blood and cerebrospinal fluid or rarely cerebral substance from the external meatus. Blood which has entered the ear from the meatus should not be mistaken for the hemorrhage of a fracture. The blood and fluid may continue flowing for a number of days. Examination shows a rupture of the drum or a laceration of the superior wall of the meatus. Emphysema of the adjacent scalp indicates that the fracture has entered the mastoid cells. Paralysis of the seventh and eighth nerves, with facial palsy, tinnitus, or deafness, is not uncommon.

Fractures of the posterior fossa follow blows upon the vertex or side of the head, or falls on the feet or buttocks. There is great danger of early involvement of the medulla and death.

Diagnosis.—1. *Fracture of the anterior fossa* may be shown by loss of blood and spinal fluid through the nose, with anosmia.

2. *Fracture of the middle fossa*—by proptosis, subconjunctival ecchymosis, the escape of blood and cerebrospinal fluid from the ear, or occasionally, where the drum is not ruptured, the blood may pass through the eustachian tube into the throat. There may be associated deafness and facial paralysis.

3. *Fracture of the posterior fossa* usually is through the petrous portion of the temporal bone. There is escape of fluid, blood, or brain substance from the ear or eustachian tube into the throat, with Battle's sign or rarely a hematoma in the pharynx.

Prognosis.—Basilar fractures are very serious, the mortality being 60 per cent. Death occurs from shock, cerebral compression, secondary edema of the brain, infection, meningitis, sinus thrombosis, or cerebral abscess. A fatal meningitis usually follows fractures of the anterior fossa into the nose.

Treatment of fracture of the skill is that of the associated intracranial injury or infection.

1. Routine Treatment of Fractured Skull.—Record patient's condition as to consciousness, coma, spasm, or flaccidity; noting pupils, pulse, respiration, temperature, and blood-pressure. If the systolic pressure is below 60 mm. of mercury, the patient should be treated for shock by rest, quiet, inclination of the head of the bed. *Open wounds* are filled with dichloramin-T, packed with gauze, the surrounding skin painted with iodin, and an occlusive dressing applied, making sure that hemorrhage is arrested. Serious injury of the chest or abdomen with internal hemorrhage having been eliminated by examination, 60 gm. of magnesium sulphate in 120 c.c. of water are introduced by rectum, and the patient watched until the temperature reaches normal and the systolic pressure is 80 or above. The patient is then carefully given: (a) *General neurologic examination.* (b) *Examination of eyes* including fundis oculi (c) *Lumbar puncture*, with examination of cerebrospinal fluid and a record of the spinal pressure. (d) *Roentgen study* of the skull and upper spine. If the spinal pressure in a horizontal position is above the normal of 10 mm. of mercury, if there is free blood in the fluid and no clinical evidence of extradural pressure, enough fluid is permitted to slowly escape to reduce the pressure to normal or, if the pressure is above 25, to 15 mm. of mercury. With high pressures the spinal tap is repeated every eight hours, or until the pressure drops to normal or the symptoms improve. In all cases the magnesium-sulphate enema is repeated every three hours to reduce the intradural pressure, and to prevent secondary cerebral edema. In adults 10 gr. of calomel may also be dusted upon the tongue. *Cranial decompression* is performed only for evidence of cortical pressure, as shown by hemiparesis or monoplegia, jacksonian convulsions, motor or sensory aphasia. The decompression is made on the side of the injury, on the side of the dilated pupil, opposite to the side of the paralysis, usually first over the anterior branch of the middle meningeal artery. Decompression is not made for basilar injury, or for injury

without definite evidence of intracranial pressure or hemorrhage. It is harmful for the pressure of an edema of the brain, but useful to relieve the the pressure of blood, serum, or bone upon the cortex. If the intracranial tension increases, as indicated by respiratory depression and increased pulse pressure, 100 c.c. of a 15 per cent. solution of sodium chlorid are given by vein at the rate of 10 c.c. every five minutes. Ventricular taps through the posterior horn of the lateral ventricle, or through Keen's point, should be made if there is increasing stupor and depression of reflexes.

2. Treatment of the Wound.—As soon as the patient has reacted from shock, the upper part of the body should be elevated, the scalp about the wound carefully shaved, cleansed with ether, and painted with $3\frac{1}{2}$ per cent. strength tincture of iodin; the dichloramin-T packs then removed from the wound, the edges of which should be débrided by a sharp knife with the removal of devitalized, ragged, dirt-infiltrated tissue. The wound should then be carefully swabbed with 5 per cent. phenol or other antiseptic, the skull carefully examined for fracture, depressed bone raised or removed, hair or other foreign material caught in a fracture removed by rongeuring the adjacent edges of bone. Pulpified brain and embedded foreign bodies are washed away by gentle irrigation with normal saline, using a soft-rubber catheter and funnel (Cushing). *Foreign bodies* in the cerebral substance are localized by a soft catheter (used as a probe) and removed. The cavity in the brain filled with a 2 per cent. solution of dichloramin-T, hemorrhage carefully arrested, the dura closed, if possible, and the overlying scalp united by interrupted silkworm-gut sutures without drainage after careful arrest of hemorrhage.

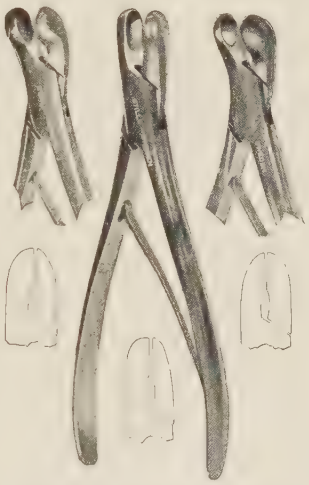


Fig. 509.—Cushing's rongeurs.

Operation upon the skull is performed only for the removal of devitalized or infected tissue or foreign body, the relief of pressure, and for the closure of wounds.

Diseases of the Skull.—Acute Osteomyelitis: *Etiology.*—Osteomyelitis of the skull occurs as a primary condition with or without contusion or abrasion (in children), or as an infection, secondary to wounds, fractures, furuncles, carbuncles, abscesses, sinusitis, or typhoid or other exanthematous fever.

Symptoms.—The condition usually begins with a chill, followed by temperature of from 103° to 105° F.; with backache, headache, and later localized tenderness and, after several days, swelling of the scalp. There is dizziness, stupor, delirium and, at times, a typhoid state. Progressive necrosis and sequestration may occur, involving a large area of the skull with abscess and sinus formation.

Prognosis is grave. Sepsis, pyemia, meningitis, sinus thrombosis, encephalitis, or cerebral abscess may complicate the bone infection and cause death.

Treatment.—The early *abortive* treatment is to incise the periosteum subcutaneously by a tenotome for periostitis, or to drill into the diploë for

osteomyelitis. Later, if pus forms, the bone is opened to secure free drainage; and still later, operation, disinfection, and removal of a sequestrum may be necessary.

Syphilis.—*Hereditary* syphilis of the skull is rare and usually is characterized by gummata of the frontal bone. *Acquired* syphilis is common, producing a gummatous periostitis, or gummata in the diploë.

Pathology.—Soft, jelly-like, pale red masses of new tissue with yellow inclusions, beginning in the periosteum or, less frequently, the diploë; with secondary necrosis, caries, ulceration, and fistulous formations.

Symptoms.—One or more bosses, from 1 to 5 cm. in diameter, which are subaponeurotic, convex, immovable, fixed to the bone, especially the frontal (*corona veneris*) or parietal bone. When acute, the condition may be painful. The masses usually develop slowly and painlessly, and disappear under proper treatment. If untreated, there is necrosis, liquefaction and absorption of bone, the production of osteophytes and sequestra with suppuration, ulceration, and sinus formation. The edges of the ulcers are thin and undermined, the opening exposing the characteristic wash-leather slough, or necrotic bone. The bone is rough and worm-eaten, the destruction exceeding bone production. The sequestra often are large, and are held by the surrounding living bone.

Prognosis.—In untreated cases, the chronic toxemia may cause secondary cachexia and amyloid disease, and may be complicated by erysipelas or septic involvement of the meninges and brain. These complications cause death in one-third of the severe cases.

Treatment.—In the early stage, very active antisyphilitic treatment should be given. Large doses of iodids are especially valuable. In obstinate cases up to 40 gm. (600 gr.) of potassium or sodium iodid may be given daily. Necrotic bone or sequestra should be removed, the remaining cavity and ulcers being filled and dressed with 50 per cent. bismuth subiodid in petrolatum. The usual intravenous injections of arsenicals are to be used. Bony defects are usually spontaneously repaired. Occasionally (nine months after complete healing, to insure asepsis) a secondary osteoplastic operation is desirable to correct the residual deformity.

Tuberculosis of the skull chiefly involves the vault, the mastoid, the temporal process of the malar bone, and the orbital margins and plates.

Symptoms.—The condition usually begins in the diploë of children, with painless cold abscesses that perforate the bone and spread to the scalp, causing a fluctuating, purplish swelling and later chronic fistulæ.

Diagnosis.—A disease usually found in childhood, beginning in the diploë with the formation of small non-adherent sequestra, and a collection of a thin cheesy pus between the dura and the skull. Syphilis particulary affects adults who often show other syphilitic lesions, begins in the periosteum as a periostitis or gumma; there usually is no pus between the dura and skull, sequestra are large and adherent, the contents are of pinkish-yellow gummatous material, and the frontal bone is chiefly affected.

The *prognosis* depends upon the extent of the local disease and the patient's general condition. The mortality is about 50 per cent.

Treatment is nutritional, radiant, and the injection of tuberculin. Bismuth

paste is useful in open wounds and sinuses. If suppuration has occurred, the area may be sterilized by zinc chlorid, excised, and closed. Bony defects may spontaneously close after the tuberculous process has become arrested. If possible, a mixed infection should be prevented.

Rickets (Rachitis).—*Etiology.*—Rickets occurs in children, three months to three years of age, from lack of vitamins A and D.

Pathology.—In the skull, rickets is characterized by absorption of developed bone, the overdevelopment of lime-deficient bone, and the deposit of a delicate pink or purplish porous material. The periosteum is red and thickened.

Symptoms.—There is enlargement of the anterior fontanel, with closure delayed from the twelfth month up to the thirty-sixth month. The softening involves the bone along the suture lines. *Craniotabes* are areas of softening and absorption, occurring especially in the occipital region. *Parrot's nodes* are thickened areas about the ossific centers of the parietal and frontal bones or tuberosities, producing the "*square head.*" The occiput is soft, sensitive, and usually flattened from pressure; the head is not enlarged, but appears large when compared with the body. There is deepening of the middle fossa, a flattening of the ring of the foramen magnum, and irregular osseous deposit at the periphery of the base of the skull. Secondary rachitic bony sclerosis or eburnation occurs associated with the general symptoms of rickets.

Prognosis.—Rickets is spontaneously arrested by the third year, but the eburnation and deformity of the skull may persist.

Treatment is dietetic and hygienic and should include sunlight and an ample supply of the fat-soluble vitamin A, which is synthesized by plants, is found in orange-juice, lettuce, spinach, carrot-tops, turnips, butter-fat, and cod-liver oil, but not in tallow or lard; and also vitamin B, which is present in cod-liver oil.

Osteomalacia of the Skull.—*Etiology.*—The disease develops in pregnant and puerperal women.

Pathology.—The bones of the skull show a thin external layer of compact bone, with bright red, soft, easily cut interior.

Symptoms.—The forehead becomes broad and convex, the occiput protrudes, the head is large, with irregular protuberances and large superciliary and orbital ridges. There is associated bending and deformity of the long bones.

Treatment.—Usually unsuccessful, should be dietetic and hygienic, with supply of calcium, parathyroid, and phosphorus. Oöphorectomy or panhysterectomy are valuable at times.

Senile Atrophy of the Skull.—This is an eccentric atrophy with symmetric depressions, occurring chiefly in the parietal region.

Pathology.—There is a thinning of the diploë from absorption of the bony trabeculæ, with associated thinning of the cortical plates. The bony depressions may be mistaken for depressed fracture or syphilis. The thinning of the skull favors fracture from slight violence, and the patient is usually bald.

Symptoms.—There are no subjective symptoms.

Treatment.—Beyond protection of the weakened skull, no treatment is required.

Leontiasis is characterized by a diffuse cranial sclerosis with enormous thickening (4 to 5 cm.) of the bones of the skull, and with obliteration of the diploë.

The enlargement usually is uniform and symmetric, with a great increase in the weight of the bone.

Etiology.—The cause of leontiasis is obscure, although attacks of erysipelas may favor the condition.

Symptoms.—A great overgrowth of the bone of the skull and face, causing contraction of the cranial cavity and narrowing or occlusion of the orbits, nares, sinuses, and foramina of the skull. The condition may lead to exophthalmos, myopia, amaurosis, anosmia, dyspnea, headache, neuralgia, palsies, psychic change, and dementia.

Diagnosis.—*Osteitis deformans* (Paget's disease) is characterized by marked changes in the spine, skull, and long bones, and does not involve the facial bones. *Acromegaly* affects not only the face but also the hands and feet; does not, however, lead to an encroachment upon the cavities of the skull.

Prognosis.—The disease pursues a slow but continued course, often beginning in youth and progressing for thirty or forty years.

Treatment.—No effective treatment is known; rarely, operative excision of the dense bone by chisel, rongeur, gouge, or burr may be desirable to relieve pressure symptoms.

Paget's Disease of the Skull (Sir James Paget, 1877).—The skull is enormously thickened, with obliteration of the sutures and diploë, the bone being fairly porous or eburnated and of great density. The disease begins after middle life, and continues many years with gradual enlargement and increasing asymmetry of the skull. As the bones of the face are not involved, the face becomes triangular with the base above. Characteristic changes in the long bones may be associated. Headache, mental impairment, and other pressure-symptoms finally develop, or sarcoma involves the diseased bone.

Treatment is unsatisfactory. Calcium, iodids, thyroid, and parathyroid may be tried.

Echinococcus cysts rarely involve the skull. When present, the cysts usually lie between the tables of the frontal or sphenoid bone.

Diagnosis.—Central enlargement of the bone, with thinned and possibly crackling outer table, under which is a cyst containing clear fluid with characteristic hooklets.

Treatment.—After injection with 2 per cent. formaldehyd or $3\frac{1}{2}$ per cent. tincture of iodin, the cyst is opened, asepticized, excised or erased, and the wound closed.

Tumors of the Skull.—Osteoma of the Skull.—Exostoses occur in several forms. *Varieties:* (1) *Exostosis of the vault*, usually involving the frontal or parietal bone as single or occasionally multiple, compact, ivory-like masses. These are often pedunculated, may project internally compressing the brain, or originate in the diploë and separate the plates. Ivory-like osteomas are most common. (2) *Velvet-like osteophytes* originate from the inner table during pregnancy. (3) *Exostosis of the orbit* grows from the superciliary arch, from the ethmoid plate of the frontal or sphenoidal sinuses, and displaces the eye and obstructs the nasal fossa. The growth is often encapsulated, and may perforate adjacent bony walls. Usually the slowly growing bony mass develops about puberty, with swelling, empyema of the sinuses, and displacement of the eye.

Treatment.—Osteomas of the skull produce disfigurement, pressure and obstruction, and should be excised if practicable. As growths springing from bones that develop from membrane tend to be ivory-like, excision may be very difficult, and the danger of fracturing the skull great. Removal should be accomplished by the surgical engine and burr, rather than by chisel and mallet.

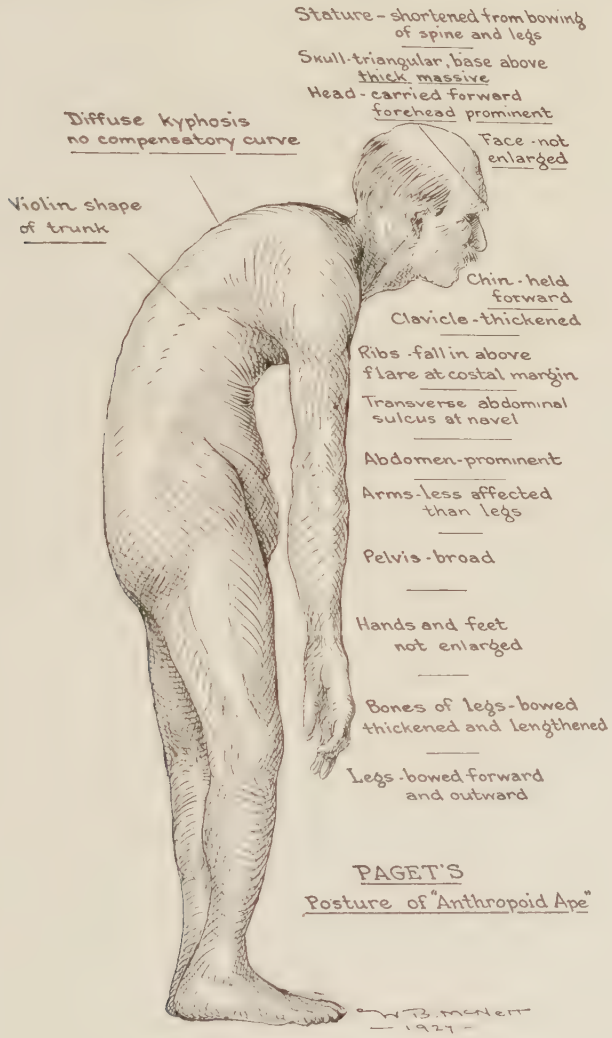

Stature - shortened from bowing of spine and legs
Skull - triangular, base above thick, massive
Head - carried forward
forehead prominent
Diffuse kyphosis
no compensatory curve
Face - not enlarged
Violin shape of trunk
Chin - held forward
Clavicle - thickened
Ribs - fall in above
flare at costal margin
Transverse abdominal sulcus at navel
Abdomen - prominent
Arms - less affected than legs
Pelvis - broad
Hands and feet not enlarged
Bones of legs - bowed thickened and lengthened
Legs - bowed forward and outward
PAGET'S
Posture of "Anthropoid Ape"

Fig. 510.—The deformities of Paget's disease.

Giant-cell tumors, formerly called giant-cell sarcoma, grow from the diploë, are well localized, spread to the bony plates, do not perforate the dura or pericranium, and do not metastasize or recur when thoroughly removed. The thinned external table may give egg-shell crackling on pressure. They should be *thoroughly excised.*

Sarcoma may be primary or secondary. Primary sarcoma may be: (1) *Peri-*

osteal. (2) *Myelogenous*, developing from the diploë and separating the tables of the skull; or (3) *dural.*

The temporal, frontal, and occipital bones are chiefly involved, and the growth may rapidly follow traumatism. Sarcoma of the skull also occurs secondarily from sarcoma of long bones, kidney, thyroid, or other organs.

Pathology.—The growth is either *spindle-* or *round-celled*, a *myeloma*, an *osteosarcoma*, or a *chloroma.* The *osteogenic periosteal sarcoma* has a skeleton of thin, newly formed bony plates and spicules, radiating at right angles from the skull. *Myelomas* are multiple, occur in the diploë, and are associated with Bence-Jones proteinuria. *Dural sarcoma* produces symptoms from intracranial pressure followed by perforation of the skull.

Diagnosis.—*Periosteal sarcoma* forms a rapidly growing mass under the scalp and may have a central bony skeleton. The bone is not elevated or perforated, and there is no pulsation. The *central sarcoma* and *myeloma* form a mass in the diploë, with thinning of the external table and egg-shell crackling; there is bone on the outside of the tumor, and no pulsation. The *dural sarcoma* produces early cerebral symptoms from pressure, and later perforates the skull, the bone being absorbed and not elevated. The growth pulsates with the brain.

Prognosis is bad. Sarcoma may invade the brain directly or give metastasis.

Treatment is free excision (including the involved scalp, skull, dura, and brain) with closure. To cause absorption of inoperable growths, radiation may be used. In the multiple myeloma, operation is useless.

Defects of the skull are closed by: 1. **Autoplastic Operation:** A cranial periosteal flap—a section of rib, scapula, costal cartilage, or tibia from the same individual being used. A free transplant of pericranium with a thin attached layer of the outer table of the skull is preferred.

2. **Homoplastic Operation:** Bone, cartilage, or fascia from another individual is used.

3. **Heteroplastic Operation:** The tissue is taken from a different species of animal. Boiled alien bone may be used. This is subject to later absorption.

4. **Alloplastic Operation:** A foreign substance is used, as celluloid, horn, metal (silver, gold). This is not advised.

Membranous replacement for the dura includes the use of pericranium, fascia lata, fat, peritoneum, hernial sac, fish bladder, gelatin paper, gutta-percha. Foreign substances are rarely desirable.

CHAPTER XXXIII

THE MENINGES AND BRAIN

MENINGES

Meningitis.—Etiology.—Inflammation of meninges usually results from infection by the Staphylococcus aureus, the Streptococcus, Pneumococcus, the Diplococcus intracellularis, the Bacillus influenza, the B. coli, and the B. pyocyaneus. Most frequently the infection follows purulent otitis media, either through a perforation of the tegmen tympani or wall of the sigmoid groove, along the emissary vein, or by extension along the sheath of the acoustic or facial nerve.

Compound fractures of the skull, infections of the nose and the accessory sinuses, and those spreading along the emissary veins, from wounds, erysipelas, boils, carbuncles, or other infection of the face and scalp may lead to meningitis.

The infection may involve the external or internal surface of the dura, causing external or internal *pachymeningitis;* or the *pia-arachnoid*, causing *leptomeningitis.*

Pachymeningitis externa, inflammation of the outer surface of the dura.

Etiology.—Infections from: (1) Contusion, open wound, or fracture of the skull; (2) disease of the cranial bones, especially tuberculosis and syphilis; or from (3) inflammation of the middle ear or nasal sinuses. The dura becomes red, thickened, covered by exudate and granulations. The exudate consists of serum, fibrin, or pus. In *extradural abscess* the overlying scalp becomes swollen and edematous, there is often a chill, followed by fever, local headache, and tenderness.

Internal Hemorrhagic Pachymeningitis.—Inflammation of the inner surface of the dura may rarely develop as a purulent extension from a leptomeningitis. Internal hemorrhagic pachymeningitis elects elderly men who have been alcoholics, or who are cachectic or anemic. There is a sheeting of subdural hemorrhage, the blood being more or less clotted, often associated with a thin subdural membrane, and flattening and wasting of the convolutions from pressure.

Symptoms often are slight and indefinite; headache, delirium, dementia paralytica, stupor, or convulsions may occur.

Treatment.—*Craniotomy* under local anesthesia, and removal of blood and new membrane, provided the patient is in condition to withstand the operation.

Leptomeningitis.—Septic inflammation of the pia-arachnoid is very serious on account of the slight resistance of the brain to infection. It may involve chiefly the (1) *base* or (2) *convexity;* or may be (3) diffuse or *cerebrospinal.* It is usually secondary to middle-ear disease, cerebral abscess, injury, a metastatic process, or is a part of a general septicemia. A purulent greenish exudate forms, especially in the sulci. The adjacent brain is congested, and the ventricles usually distended.

General symptoms of meningitis develop in forty-eight to seventy-two hours after injury: (1) *Severe headache.* (2) *Pyrexia, rigor* or chill, with *cutis anserina* and a temperature of 102° to 105° F. (3) *Bradycardia*, the pulse is slow, small, wiry, and irregular; in the later stages becoming rapid and feeble. (4) *Respiration slow* and irregular, becoming *Cheyne-Stokes.* (5) *Miosis* early; *mydriasis* and inequality later. (6) *Cerebral vomiting* without relation to food or nausea. (7) *Mental irritability*, restlessness, coma, convulsions occur from involvement of convexity, with clonic spasms and paralysis which may be limited to the face and arms. In children, the *meningeal cry* occurs, which is sharp, short, piercing, and without evident cause. (8) *Obstipation.*

Gradenigo's syndrome (severe trifacial pain and abducent paralysis following middle-ear infection) depends on the extension of the infection through the cells of the mastoid to the region of Meckel's cavity or the gasserian ganglion, and the involvement of the sixth nerve in Dorello's canal. Meningeal edema may cause the syndrome, and recovery may occur without surgical drainage.

Basilar meningitis is a meningitis chiefly affecting the base of the brain. There is pain, stiffness in the muscles of the back of the neck with retraction of the head, and *involvement of the cranial nerves*, shown by strabismus, facial paralysis, deafness or tinnitus; frequently bulbar neuritis associated with bulbar irritation or paralysis, evidenced by changes in the respirations and pulse.

Cerebrospinal meningitis produces symptoms resembling cerebral leptomeningitis but more widespread and intense. Usually it is rapidly fatal.

Varieties.—Pneumococcic meningitis may be *primary* or a part of a pneumococcic septicemia, or *secondary* to otitis media, sinusitis, empyema, pericarditis, or other rather distant infections. There is thick, profuse, yellowish, odorless exudate, which may be most marked at the vertex or base, and usually involves the cord. The onset is rapid, and death almost invariably follows in three or four days.

Staphylococcus aureus meningitis produces a free purulent exudate, and death results within a few days.

Staphylococcus albus meningitis may run a rather progressive course of six to eight weeks, with thick purulent exudate, emaciation, and death.

Diplococcus intracellularis meningitis occurs as a primary infection chiefly in children. The cerebrospinal fluid shows an increased cell-count, usually without pus formation. The mortality with serum treatment is about 30 per cent.

Streptococcic meningitis is usually intense and rapidly fatal. From the hemolytic streptococcus recovery may occur, as also from the rarer influenzal or typhoidal meningitis.

Meningism, which is not fatal, occurs in acute pneumonia, typhoid fever, and influenza, occasionally in middle-ear disease or alcoholism. It produces less intense symptoms, without the characteristic changes in the cerebrospinal fluid except an increase in pressure.

Diagnosis.—Convulsions without paralysis suggest meningitis; convulsions with paralysis, pressure or tumor involving the cortex. The spinal fluid shows leukocytosis; with an excess of mononuclear leukocytes in *tuberculosis*, and of

polynuclear leukocytes with a high blood leukocytosis in *pyogenic infection.* In pyogenic infection death usually occurs on the third or fourth day.

Treatment of Meningitis.—(1) Absolute rest in a quiet, darkened room. (2) Ice-cap to the head. (3) Fowler's position. (4) Repeated lumbar punctures for drainage and to maintain a low cerebrospinal pressure. (5) Antitoxins intrathecally and intravenously.

Prophylactic Treatment: (1) *Débridement* of all head wounds, with asepsis and antisepsis and closure of the scalp. (2) Up to 8 gm. of *methenamin* daily by mouth, rectum or intravenously, the use of appropriate *vaccines* and antitoxins, the latter may be injected intradurally. (3) *Local drainage.*

Treatment of Septic Meningitis.—1. *Repeated lumbar punctures* (intermittent drainage).

2. *Continuous drainage* from: (a) Spinal canal. (b) Cisterna magna. (c) The pontine cisterna. (d) The lateral ventricle. (e) The subarachnoid space.

3. *Irrigations* of the subarachnoid space are usually fatal and not advised. Continuous drainage from the cisterna is preferred. *Haynes' operation* is used for a basilar meningitis of children: An occipital flap is turned down, the bone removed exposing the cerebellum and the cisterna magna. Pus and lymph are removed, and a drain inserted to but not through the dura.

Chronic meningitis may follow head injury, and may cause a secondary thickened patch on the membranes, or adhesions to the bone or brain.

Symptoms include: (1) *Headache;* (2) *tenderness* that is constant, fixed and localized; (3) at times *traumatic epilepsy,* mental instability, a tendency to alcoholism.

Treatment.—Rest, absence of excitement or stimulation, iodids, blistering the scalp and, for the obstinate type, craniotomy and decompression.

Syphilitic meningitis, characterized by severe headache with mental symptoms, or cranial nerve paralysis may be precipitated by injury. The symptoms are persistent but often intermittent.

Treatment.—*Massive iodism* (from 12 to 40 gm. of sodium or potassium iodid are given daily), with the intravenous use of arsenicals, and the subcutaneous injection of bismuth. If the condition is not relieved by two months of treatment, craniotomy and decompression are advisable.

Tuberculous meningitis chiefly involves the base.

Etiology.—Usually occurs in children between two and five years of age.

Symptoms. 1. *Prodromal:* After a fall or other injury, or following measles or whooping-cough, the child becomes peevish, loses appetite, wastes, and after two to six weeks gives evidences of meningeal irritation and hyperesthesia (convulsions, headache, vomiting, temperature of 102° to 103° F.; rapid pulse, becoming slow and irregular), with constipation, hydrocephalic cry, contracted pupils, restlessness, muscular twitching, strabismus, photophobia, increased cerebrospinal pressure.

2. *Second Stage:* The patient lies on his side with the elbows and knees flexed, is drowsy and irritable, resists feeding or moving, and has difficulty in swallowing. The pupils are dilated or unequal, the reaction to light is altered, ocular movements are incoördinated; strabismus, ocular neuritis, and ptosis may be present. The abdomen is retracted with constipation. Vomiting and

headache are less marked, the temperature falls to 100° to 102° F. Convulsions followed by rigidity occur. The pulse is slow and irregular, the respirations slow, the head retracted, the muscles of the posterior neck spastic. The skin shows the *tache cérébrale* and erythematous eruption, the cheeks are often flushed.

3. *Third stage* is marked by paralysis, deepening coma, convulsions, spasms, and contractions; the pupils are dilated, the eyelids partially closed, and the pulse rapid. There is diarrhea, incontinence, and typhoid state with a low temperature. Before death there may be hyperpyrexia (106° F.).

Duration is about three weeks, the acute form being fatal in a few days. Spinal fluid shows increased pressure, increased protein, excess of small lymphocytes, and tubercle bacilli. The fluid is clear or slightly turbid. The blood shows a polymorphonuclear leukocytosis of 15,000 to 30,000. The tuberculous reaction is present early but not later. In adults prodromes are rare and the early symptoms may be diplopic squint, alteration in speech, vomiting, less frequently a monoplegia or hemiplegia, and sometimes aphasia. The condition may suggest hysteria. Delirium, muscular twitching, and rigidity are common. General convulsions are rare. Coma is of rapid onset and short duration.

Prognosis.—Very few recoveries are recorded.

Treatment.—Repeated lumbar punctures may be made to reduce pressure and to relieve the pain.

BRAIN

Cortical Localization.—The upper third of the precentral gyrus governs the foot, knee, hip, and trunk; the midthird—the shoulder, elbow, wrist, fingers, and thumbs; the lower third—the neck, nose, lips, jaw, and eyelids.

Anterior to the juncture of the lateral cerebral fissure (Sylvius) and central sulcus (Rolando) lie the centers of the tongue, palate, larynx, and vocal cords. The posterior part of the inferior frontal gyrus on the left side (in right-handed persons) is Broca's area, the center of motor speech, injury of which produces motor aphasia. The posterior part of the left middle frontal gyrus is the center of motor writing, the loss of which causes agraphia.

The *cortical representation* for common tactile sensation is in the postcentral gyrus in proximity to that of motion in the precentral convolution. The cortical representation for sensation of the face is in proximity to that for sensation of the hand. Sensory involvement of the radial part of the forearm and hand and lower part of face on the same side indicates a contralateral lesion of the lower part of the posterior central gyrus.

The superior parietal lobule is concerned with the recognition of objects by touch, stereognosis; and *astereognosis* follows the involvement of this part.

Occipital Lobe.—The cuneus is the center for vision; unilateral lesion gives rise to a homolateral homonymous hemianopsia. Injury of the left angular gyrus causes word-blindness.

Large portions of brain, especially from the so-called silent areas of the frontal and occipital lobes, may be removed without serious secondary symptoms. By re-education of undestroyed areas aphasia and paralysis may be overcome.

Decerebrate Rigidity.—Spasm of the voluntary muscles follows the removal of the brain of the living animal. In the experimental animal, with the re-

moval of successive slices of brain, muscular rigidity does not appear until the level of the thalamus is reached.

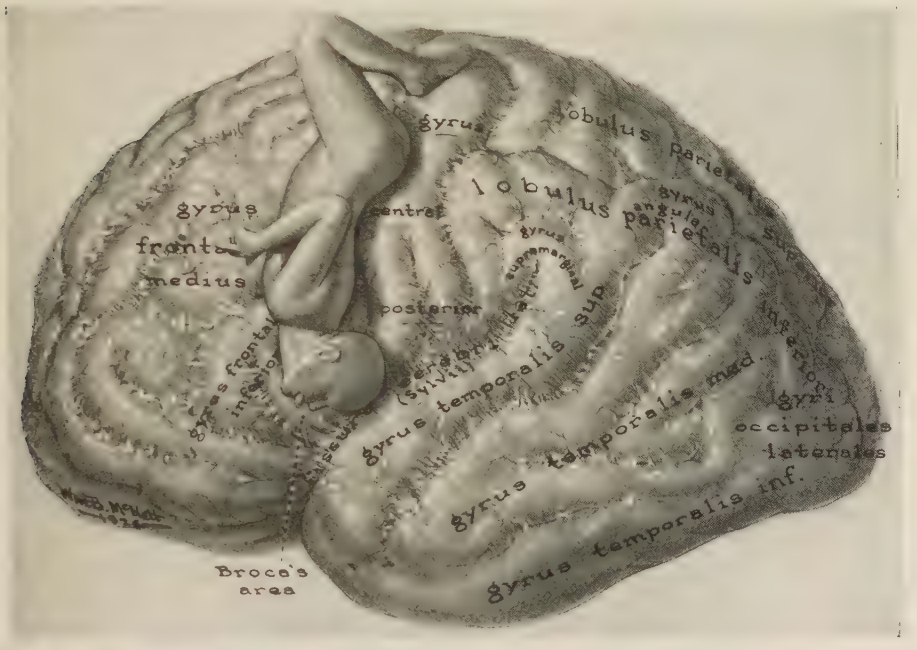


Fig. 511.—The cortex of the brain. The superimposed figure upon the precentral convolution suggests the approximate cortical motor representation.

In a number of diseases characterized by muscular rigidity, tremor, choreiform movements and athetosis, lesions of the thalamus, the striatum (Huntington's

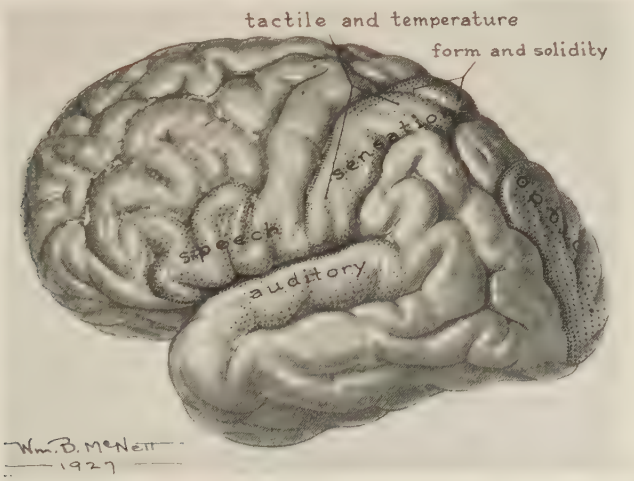


Fig. 512.—Cortical centers of the brain.

and Sydenham's chorea), the closely related subthalamic structures and especially that portion of the pons known as the tegmentum have been found.

Especially have lesions in the tegmentum shown involvement of the nucleus ruber, the rubrospinal fasciculus, and the substantia nigra (paralysis agitans, postencephalitic parkinsonismus). These basal structures are exposed to injury and pressure in fractures of the posterior fossa of the skull. Particularly may the midbrain be damaged when the momentum of the moving head is suddenly arrested and the inertia of the after-coming body drives in the base of the skull. With a ring-fracture, the margins of the foramen magnum may be driven into the skull against the brain. Fractures of the posterior fossa, with contusion of the pons and adjacent structures, may immediately cause muscular rigidity. As would be expected from its contiguous situation, symptoms of medullary injury are often associated.

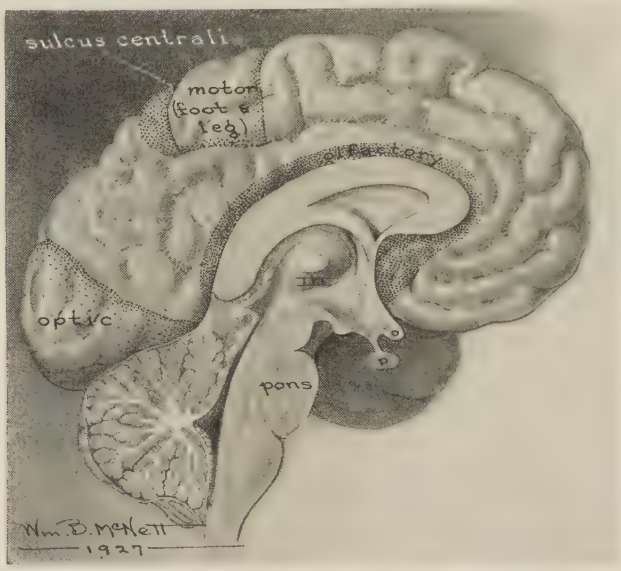


Fig. 513.—Cortical centers of the brain along the great medial fissure: *P*, Pituitary.

Cerebellum.—After nearly total removal of the cerebellum, life continues. The patient is able to walk, though with difficulty, and to speak, but with great hesitation. With removal of a part of the cerebellum, or of one lobe, the symptoms may be slight, as the residual portion compensates for that removed.

The *cerebellum* is concerned with the maintenance of equilibrium, of muscle-tone, and of co-ordination of the muscular movements. Each lateral lobe is connected with the corresponding side of the body, so that disease produces symptoms referable to the same side as the lesion. The lateral lobe has an inhibitory effect on the opposite cerebral hemisphere, to which it is attached by the superior cerebellar peduncle. The vermis is connected with both sides of the body.

Symptoms.—1. *General:* Headache (often occipital), vomiting, and optic neuritis.

2. *Special:* (a) *Vertigo*—the sense of rotation being away from the side of the lesion, probably from involvement of the vestibular nerve tract. (b) *Cerebellar ataxia*—reeling and lurching gait, usually toward the involved side, affecting

coarser movements and not increased by closing the eyes (no Romberg); on standing there is a tendency to sway and, in vermis lesion, to fall backward. (c) *Dysdiadokokinesia*—repeated movements more slowly and clumsily performed on the affected side, such as repeated supination and pronation of the wrist; movements may continue despite attempts to cease. (d) *Paresis* and *atonia*, weakness, paralysis and flaccidity of the limbs on the side of the lesion. (e) *Tremors*, *spasms* and rhythmic movements of the head, trunk, and limbs occur in cerebellar lesions, but are rare in tumors. (f) *Nystagmus* is common, with coarse movements on looking toward the side of the lesion. (g) *Internal strabismus* occurs from pressure upon the sixth nerve. Sensation and the action of the sphincters are not affected. The reflexes may be increased or diminished. A plantar extensor reflex (Babinski's reflex) is absent unless there is pressure.

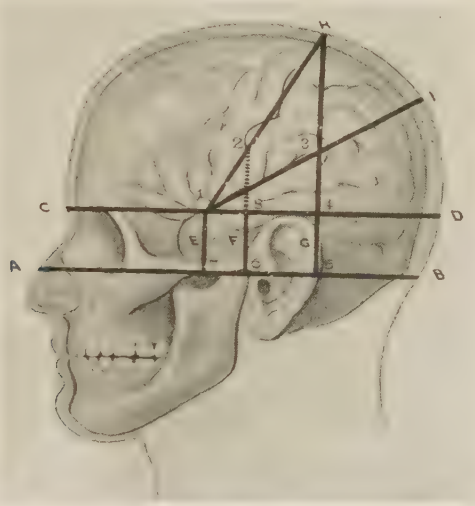


Fig. 514.—Krönlein's method of craniocerebral topography: 2–H, central sulcus (fissure of Rolando); 1–3, lateral cerebral fissure (of Sylvius). 1, point for trephining for hemorrhage from the anterior branch of the middle meningeal artery; 4, point for trephining for hemorrhage from the posterior branch of the middle meningeal artery.

Medulla.—Injuries to and pressure upon the medulla cause great variations in the rate and amplitude of the respirations and pulse. Cheyne-Stokes respiration followed by apnea often occurs and artificial respiration may be necessary to prolong life.

Craniocerebral Topography.—Krönlein's Method: 1. A *horizontal line (Reid's base line)* (A–B, Fig. 514) is passed through the lower border of the orbit and the auricular point (center of the external acoustic meatus).

2. A *second horizontal line* (C–D) is placed parallel with the first from the upper border of the orbit backward.

3. The *first vertical line* extends upward, at right angles with the first horizontal, from the middle of the zygoma (7).

4. The *second vertical line*, upward from the glenoid cavity (6).

5. The *third vertical line*, upward from the posterior border of the mastoid process (5). Where the anterior vertical line crosses the upper horizontal line (1)

is the site for exposing the anterior branch of the middle meningeal artery; and where the posterior vertical line bisects the superior horizontal line (4) is the point for exposing the posterior branch of the middle meningeal artery. A rough rule for the anterior branch is a thumb's breadth back of the orbital margin and two fingerbreadths above the zygoma.

The oblique line (1–3) bisecting the triangle, formed by the middle vertical and superior horizontal lines, overlays the sylvian fissure; the line (2–H), the rolandic fissure.

Bárány's Tests.—Normally the injection of cold water into one ear is followed by horizontal nystagmus of the opposite side, continuing one or two minutes, with a pointing error deviating to the right during the continuation of the artificially produced nystagmus. This is due to the reaction of the cerebellar hemisphere of the same side. If the portion of the right cerebellar hemisphere concerned is not functioning, past pointing does not occur. The *caloric test* shows pathology of the labyrinth itself, the *rotation tests* (revolving patient in a special chair), disease beyond the extramedullary vestibular paths.

Encephalography.—To better delineate intracranial and intraspinal structures on the Roentgen films, air or iodized oil have been injected within the membranes or ventricles. The injections are dangerous. (1) *Air Encephalography:* The patient being in a sitting posture, 10 c.c. of air are injected by lumbar or suboccipital puncture after the removal of 10 c.c. of cerebrospinal fluid, and roentgenograms are then taken. (2) *Oil Encephalography:* Ten c.c. of lipiodol are injected. This penetrates the ventricular system better than air, while the air more readily reaches the vertex. *Secondary symptoms* from the injections include fever, vomiting, headache, lymphocytosis in the fluid, and meningism. Lipiodol may cause late and prolonged symptoms, and has been found three or more months after the injection.

Hydrocephalus is an enlargement of the skull due to an excess of cerebrospinal fluid, occurring about once in 500 births. The fluid may be (1) external to the brain in the pia-arachnoid space (*external hydrocephalus*), or more often (2) within the ventricles (*internal hydrocephalus*). Hydrocephalus may be acute or chronic, congenital or acquired.

Pathology.—Cerebrospinal fluid is secreted by the ependyma of the choroid plexus of the lateral ventricles, and passes from the ventricles through the foramina of Magendie and Luschka to the fourth ventricle and subarachnoid space, to slowly circulate down the posterior surface of the spinal cord and up the anterior surface; to be finally absorbed by the pia-arachnoid veins, especially those entering the superior longitudinal sinus. Excessive secretion of fluid (as in tuberculous or other forms of meningitis), obstruction to the foramina of Magendie and Luschka by tumor, exudate or adhesions, or interference with absorption by the veins, may result in an excess of cerebrospinal fluid or hydrocephalus.

Congenital or Primary.—The lateral ventricles are greatly distended, containing from 100 c.c. to several liters of fluid. The overlying brain may be only a few millimeters in thickness; the bones of the skull are thin and may show crackling or abnormal openings; the sutures are wide and contain many wormian bones; the fontanels are large, do not pulsate, but later tend to close.

Fig. 515.—Congenital hydrocephalus.

The bulging, dome-like head overhangs the eyes and ears of the disproportionately small face; the scalp is thin, shows little hair, and has engorged blood-

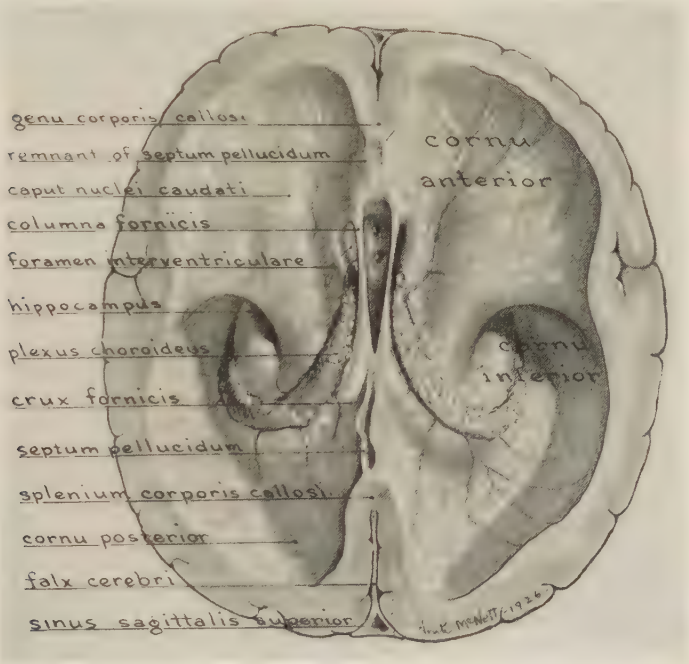


Fig. 516.—Cross-section of the brain in hydrocephalus showing the dilated ventricles.

vessels. The condition may be so marked at birth as to cause dystocia and destruction of the child. The infant is often unable to support the large heavy

head, and is quiet because crying gives distress by increasing the intracranial pressure. The upper eyelid is raised by traction of the scalp, exposing the sclera; strabismus, nystagmus, papilledema, and optic atrophy occur. Occasionally the orbit is encroached upon with such proptosis that the eyes escape from behind the lids. A discharge of watery fluid from the nose (*hydrorrhea nasalis*) may occur.

The child is slow in learning to talk or walk, and often is mentally deficient or idiotic. Convulsions, spasticity, and paralysis are common. Other congenital defects—such as spina bifida, cephalocele, porencephaly, harelip, club-foot, syndactylism—are frequently associated. The body is wasted and ill-nourished or, from stimulation of the pituitary, the infant is plump and fat.

Etiology is obscure. Although alcoholism and syphilis of the parents have been blamed, the child usually has a negative Wassermann, and many cases occur without a family history of alcoholism.

Fig. 517.—Congenital hydrocephalus.

Diagnosis.—The broad, bulging forehead with enlargement of the head in an infant is usually unmistakable. If the head, at birth, exceeds 37 cm. in circumference, 13 cm. in the occipitofrontal, and 11 cm. in the biparietal diameter, hydrocephalus is probable.

Prognosis.—If the enlargement is progressive after birth, the child usually dies within ten weeks. The process may be temporarily arrested with recurrent exacerbation, or may permanently stop. The enlargement of the skull usually continues until ossification is complete. Ninety per cent. die within the first year of life. Of those who survive, the majority are idiotic, only a few are able to attend school and, in many, ability to walk is only acquired after the patient is five years of age. Less than 2 per cent. grow to adult life, or have sufficient mentality to be self-sustaining.

Treatment is unsatisfactory. Mercury and iodids are of little or no value. Various methods, none of which is very efficient, have been suggested for reducing the quantity of cerebrospinal fluid, including: (1) *Repeated aspirations*, using a fine needle. Not over 100 c.c. of fluid should be withdrawn at a time. Aspiration is not without danger. The ventricle is often entered within 5 or 10 mm. of the surface of the scalp. The punctures may be made, every five or ten days, along the coronary sutures to the right or left of the fontanel and midway between the base and the top of the skull. (2) *Corpus callosum puncture*—the scalp and dura

are incised, and an opening (1 to 3 cm. long) is made through the roof of the third ventricle by incision of the corpus callosum. (3) *Permanent drainage from the lateral or third ventricles* has been attempted by the introduction of strands of tubular silk, decalcified bone tubes, or other tubular, conducting, or absorbent material leading from the ventricle, through the thin cortex of the brain, into the subarachnoid space or the subaponeurotic area of the scalp. The drainage is seldom efficient. (4) *Removal of choroid plexuses* (*Dandy*) through an opening into the lateral ventricles, to prevent the formation of cerebrospinal fluid, has usually been fatal.

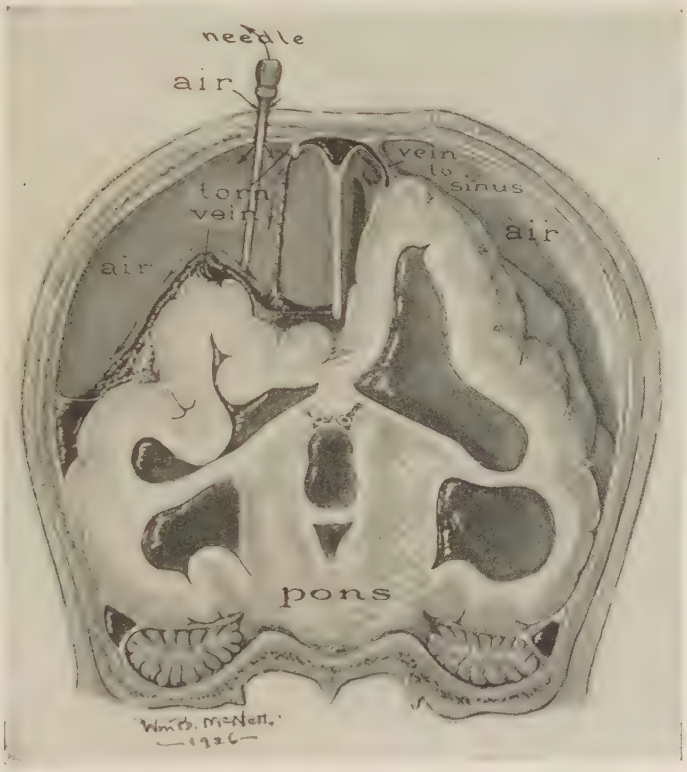


Fig. 518. Indicating possible source of hemorrhage and the entrance of air from aspirating the lateral ventricle.

Internal hydrocephalus should not be treated by spinal puncture for fear of herniation of the brain through the foramen magnum.

Secondary or acquired internal hydrocephalus occurs from interference with the cerebrospinal circulation, from tumors obstructing the veins of Galen, from cerebellopontine or cerebellar growths, or from meningitis (especially cerebrospinal), with adhesions obstructing the foramen of Magendie or producing a deposit over the absorbing veins and along the sinuses.

Idiopathic internal hydrocephalus (*Quincke's serous meningitis*) is a rare condition occurring in children or adults, and may be due to an ependymitis producing a serous effusion into the lateral ventricles.

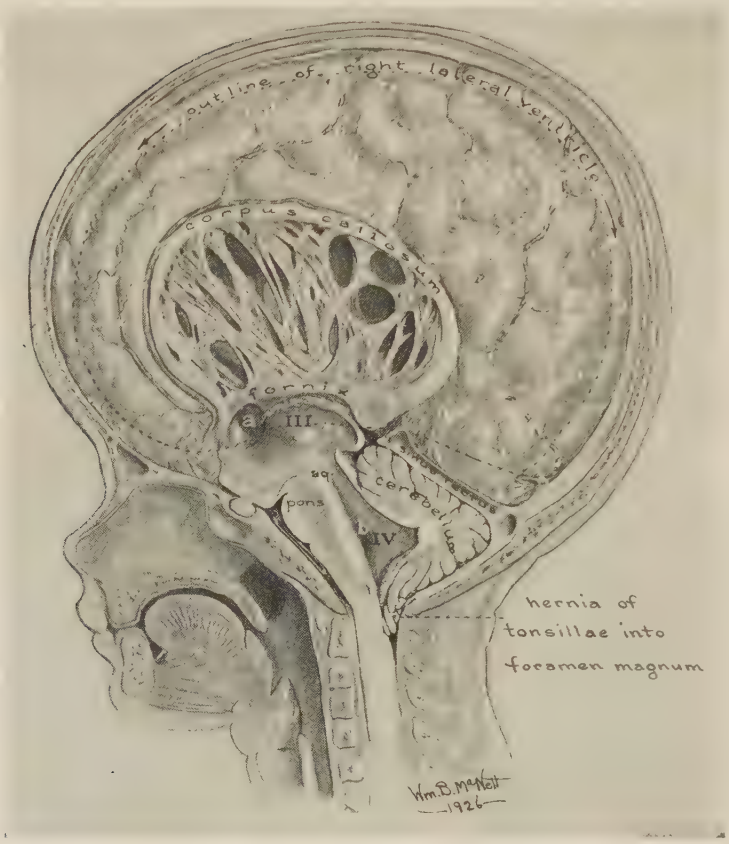


Fig. 519.—Fatal hernia of tonsillæ into the foramen magnum from spinal puncture in internal hydrocephalus. *a*, Foramen of Monro; *aq*, aqueduct cerebri; *b*, foramina of Luschka; III, third ventricle; IV, fourth ventricle.

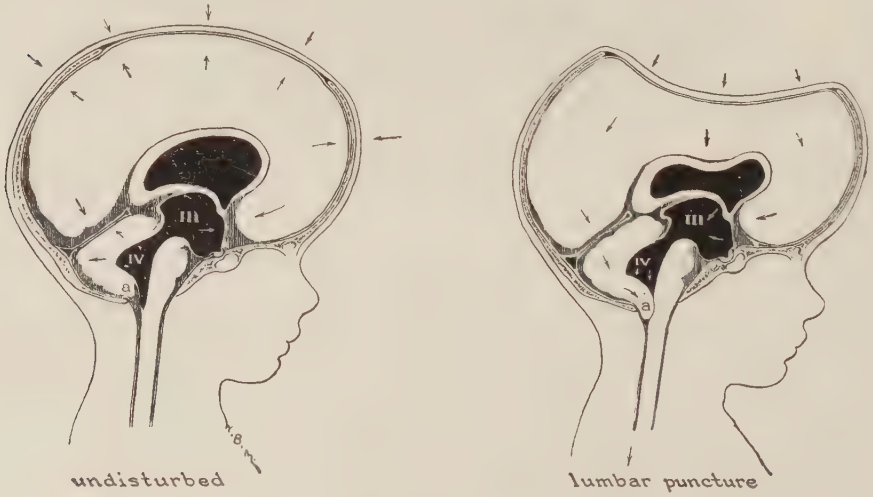


Fig. 520.—The danger of spinal puncture from foraminal hernia when there is increased intracerebral pressure.

Symptoms.—In the *acute form* it resembles meningitis, with headache, slow pulse, optic neuritis, retraction of the head; with or without increase in temperature. The *chronic form* suggests cerebral tumor, with headache, optic neuritis, vomiting, stupor, coma, convulsions, and paralysis of the cranial nerves.

Treatment.—In tumor, ventricular puncture may enable an operation to be performed or completed, and may save the life of a patient apparently dying from intracranial pressure.

In idiopathic internal hydrocephalus the patient may greatly improve, or recover, after ventricular puncture and evacuation of the cerebrospinal fluid.

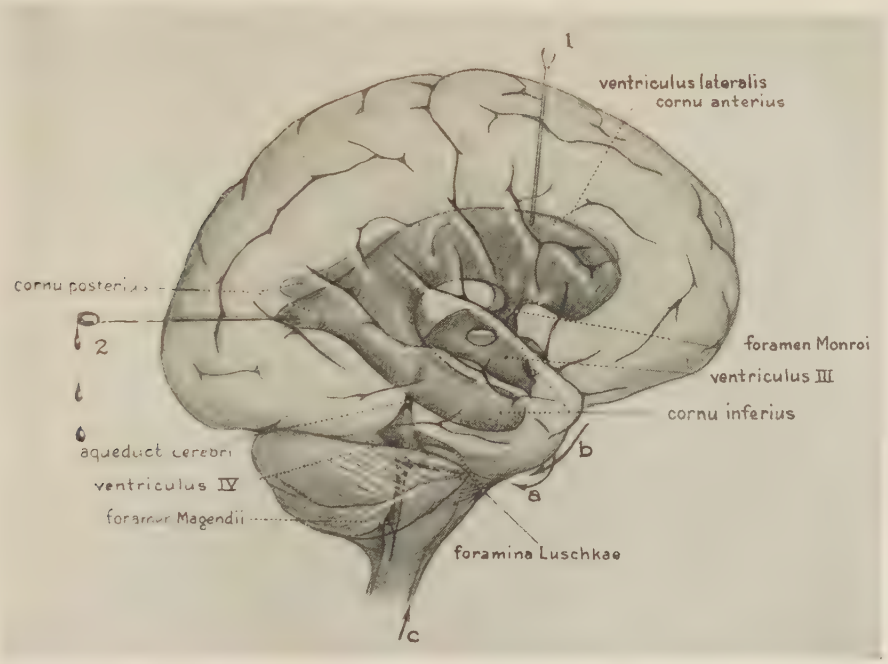


Fig. 521.—The ventricles of the brain with points for aspiration.

Puncture of the Lateral Ventricles: Local anesthesia is used if the patient is conscious. A small incision is made through the scalp, and the skull drilled by a small burr. (a) *Keen's point* is 3 cm. above and 3 cm. behind the external auditory meatus, the needle being passed for 5 cm. in the direction of the top of the opposite pinna for the adult. (b) *Kocher's point* is $2\frac{1}{2}$ cm. from the midline, $3\frac{1}{2}$ cm. in front of the bregma, the needle being passed downward and backward for 4 or 5 cm. (c) *Occipital puncture* may be made into the lateral ventricles 2 cm. above the tentorium and 2 cm. lateral to the midline.

External hydrocephalus is unusual, the fluid lying in the cavity of the arachnoid external to the brain. The brain is small and atrophic, and the child usually idiotic. In one of our patients the skull was so large that the small brain could not be reached by the examining finger introduced through an opening at the vertex.

The *prognosis* is unfavorable.

Treatment.—Repeated aspirations, or the introduction of Handley's tubular silk from the arachnoid to the subcutaneous spaces of the scalp and neck may be tried.

Cerebral concussion or **cerebral shock** is the condition of shock, not due to gross lesion of the brain, that immediately follows cerebral injury.

Pathology.—The violence transmitted directly to the brain produces little evidence of injury, except minute punctate or petechial hemorrhages that are found scattered widely through the cerebral substance. Miles has also recorded collections of colloid bodies and patches of miliary sclerosis, chromatolysis and vacuolation of the nerve-cells. With the more severe lesions larger foci with hemorrhagic extravasation and red softening of the brain substance, hemorrhagic effusion into the meshes of the pia-arachnoid under the point of the impact or at the opposite pole of the skull (the so-called *point of contrecoup*) occur. The changes in the brain are produced by violent fluid-waves set up within the skull.

Fig. 522.—Penetration of the skull and occipital sinus by an automobile bolt. Recovery.

Symptoms range from momentary dizziness to instant death. According to degree, there is: (1) *Vertigo, faintness,* and *mental confusion* with muscular weakness; the patient may become nauseated and vomit. These symptoms rapidly disappear, or pass into (2) *shock:* The skin is pale, cold, and clammy; the pulse rapid and weak, with a marked fall in blood-pressure; the respirations are short, shallow, slow, and frequently sighing; the temperature is subnormal; involuntary defecation and urinary retention occur. There is diminished cerebration, with lethargy, difficult response, disorientation, or complete unconsciousness and, at times, vomiting or epileptiform seizures. In the milder forms, improvement occurs in a few minutes or after several hours. The temperature may remain subnormal and the pulse abnormally slow for one or more weeks.

Prognosis.—Concussion results in: (1) *Complete recovery;* (2) *delayed recovery* or permanent cerebral damage, shown by secondary headache, amnesia or mental change, incapacity for sustained effort, mental instability, neurasthenia, impairment or change in memory, muscular weakness. (3) *Death.*

Prognosis should be very guarded, as concussion after a temporary period of improvement (*lucid interval*) may pass into compression, infection, and death; or serious symptoms may remain or develop after apparent recovery.

Treatment.—Absolute rest and quiet in a darkened room. External heat is applied and, if shock is marked, a nutrient enema (spirit of camphor, 4 c.c.; glucose, 60 gm.; warm saline solution, 2 liters) may be given. On reaction, the patient should be placed in the Fowler position, an ice-cap applied to the head, and a careful watch kept for complications. After severe concussion the patient should be at rest (without mental exertion) in a quiet, darkened room for two or three weeks.

Cerebral Compression.—**Physiology:** As the cerebral veins and arteries pulsate with each beat of the heart, changes in volume of blood within the skull are compensated for by alterations in the size of the veins and sinuses. An increase in volume occurs with expiration, but not inspiration,

Fig. 523.—Penetration of the occipital bone and sinus by an automobile bolt, from a fall against an automobile chassis. No pressure symptoms. Recovery.

for the reason that there are no efficient valves between the right side of the heart and the cerebral veins. Thus, the expiratory rise in venous pressure is transmitted directly to the brain. The intracranial pressure varies directly with the venous pressure in the skull, and passively follows changes of the pressure in the arteries and veins of the systemic circulation. The cerebral sinuses pulsate under a pressure corresponding to that of the brain. The cerebral vessels are normally without vasomotor activity. The intracranial pressure is equal to that in the cerebral capillaries, and is increased by compression of the veins of the neck, and by an increase of the general arterial pressure. In hemorrhage within the skull, the late symptoms are due largely to the secondary cerebral anemia, especially to the anemia of the medulla.

The amount of cerebrospinal fluid in man is from 100 to 180 c.c. Fluid lost is rapidly replaced. In fracture 200 c.c., and in cerebrospinal rhinorrhea 700 c.c. may escape daily. The arterial circle of Willis, supplied by the two vertebral and two internal carotid arteries, equalizes the circulation to the brain. Ligation of both carotids is usually fatal from reduction of the cerebral blood-supply; ligation of one common carotid causes cerebral degeneration and partial hemiplegia in about one-fourth of the cases.

The arteries of the brain are terminal in character, so that, when they are blocked or obstructed, degeneration of the corresponding portion of the brain follows. The pia mater has, however, a free vascular anastomosis. Regeneration of destroyed brain tissue does not occur, but function often is restored by education of new areas.

Etiology.—Hemorrhage, edema, inflammatory exudate, or tumors within the skull produce compression of the brain. Acute traumatic compression is due chiefly to hemorrhage from a fracture involving the squamous plate of the temporal bone. In 90 per cent. of the cases the bleeding occurs from the anterior branch of the middle meningeal artery, and in 10 per cent. from the posterior branch.

Pathology.—To compensate for hemorrhage into the skull, the cerebrospinal fluid—together with the blood in the veins, sinuses, and later the arteries—is displaced. This results in cerebral anemia and stimulation of the vasomotor center of the medulla, with oscillating increases in the general blood-pressure. Finally, as the pressure within the skull becomes as great as the pressure of blood entering the skull, there is circulatory arrest and anemia of the medulla, leading to respiratory and circulatory paralysis. In the meantime, many of the higher centers have been paralyzed, especially the cortex, with resulting stupor, coma, and paralysis. Depressed bone or foreign bodies, while capable of producing monospasm or monoparalysis, are insufficient to produce the general symptoms of cerebral compression.

The **symptoms** are due first to irritation, then depression of cortical centers, and finally to depression and paralysis of centers of the medulla from the cerebral anemia. The cortex is least resistant to anemia, and in order follow the corona radiata, the gray matter of the spinal cord, the pons, and finally the medulla.

Symptoms of cerebral compression from intracranial hemorrhage:

1. *First Stage (Onset)*: Immediately after the injury the patient usually shows concussion or is momentarily stunned or unconscious; then follows a lucid interval, succeeded by increasing headache, restlessness, hypersensitiveness, and then dulness and apathy.

2. *Second Stage (Stage of Compensation)*: Stupor occurs, and is succeeded by coma. The pupils, at first contracted, become unequal, the dilated pupil being on the side of greatest pressure. Finally both pupils dilate, with swelling of the disk and distended tortuous retinal veins. The distention of the veins of the retina indicates the degree of intracranial venous stasis. There is a marked but vacillating increase in blood-pressure; the pulse is slow, full, and strong; the skin red, hot, suffused, showing a higher temperature on the paralyzed side; the respirations are slow, snoring, or stertorous from paralysis of the soft palate, lips, and cheeks. The red engorged skin may be succeeded by cyanosis. Monospasm may occur succeeded by monoplegia or hemiplegia.

In determining paralysis one compares the tone or flaccidity of the muscles and the condition of the reflexes, especially the abdominal and cremasteric of the two sides. In a comatose patient loss of the abdominal reflex on the side opposite the injury is especially important. Increased intraspinal pressure and hemorrhagic spinal fluid accompany intradural hemorrhage. With extradural hemorrhage, spinal puncture is dangerous from the possibility of death from foraminal hernia.

3. *Third Stage* (*Loss of Compensation, Medullary Paralysis*): The pulse is rapid, weak, and running; the respirations are Cheyne-Stokes in type; the blood-pressure falls; the skin may be cyanotic; the cerebrospinal pressure increases; the rectal temperature may show hyperpyrexia (106° to 108° F.). There is retention of urine, involuntary defecation from paralysis of the sphincter ani, and finally death from paralysis of the respiratory centers.

Diagnosis.—Cerebral compression is often mistaken for alcoholism. Alcoholism frequently is responsible for fracture of the skull and cerebral compression; therefore, if there is the odor on the breath of an unconscious man, one should immediately look for fracture or other injury. With alcoholism the patient is not completely unconscious, not paralyzed, often resistant or quarrelsome, and improves after lavage of the stomach. The pupils are equal, moderately dilated, and react to light; the temperature is normal or subnormal.

Opium poisoning is characterized by stupor and by contracted pupils which do not react to light. The history, a laudanum bottle, pill-box or hypodermic syringe, the odor of opium, the breath, or hypodermic punctures on the skin may give a clue to the condition.

Uremic or Diabetic Coma.—The history of the previous disease, the acetone odor of the breath, the presence of sugar or albumin in the urine, the edema of the legs (in the uremic), and the nitrogen retention or sugar content in the blood enable the diagnosis to be made.

Status Epilepticus.—The history of convulsions, the presence of scars about the back of the head from previous falls, the bitten tongue, the bromid rash, and the involuntary urination are sufficient evidence on which to make a diagnosis. It is to be remembered that an epileptic seizure may result in fracture of the skull and intracranial hemorrhage.

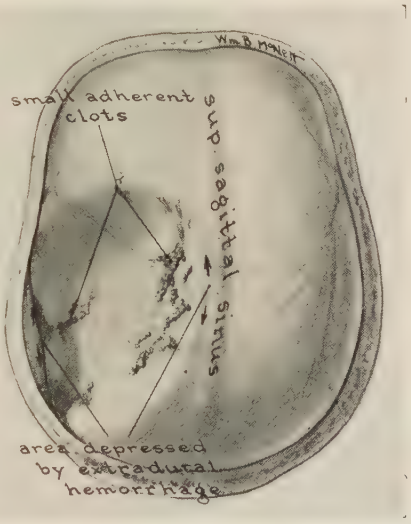


Fig. 524.—Depression in dura and brain after evacuation of extradural hemorrhage. Patient stuporous from cerebral compression. The brain slowly refilled the space after the removal of the blood.

Apoplexy or Cerebral Embolism.—In *apoplexy*, the age and evidence of vascular disease, and perhaps a preceding history of hemiplegia, are important. With *embolism*, evidence of endocarditis and cardiac enlargement are suggestive.

Coma from sunstroke or exposure to cold are characterized in the one case by hyperpyrexia, in the other by a subnormal temperature. In any case, however, the most careful examination should be made of the skull, eyes, reflexes, mouth, urine, blood, and the like, to determine that cerebral injury is not associated as a second cause for coma.

Symptoms of hemorrhage come on within a few hours after the injury; symptoms of pressure from secondary cerebral edema, after twenty-four hours; from inflammatory exudate or meningitis, usually after the third day.

Prognosis.—A temperature of 104° F. or more is unfavorable, and recovery is unlikely if the patient has passed into the third stage of cerebral compression with medullary paralysis. In the second stage, recovery of the patient may rest

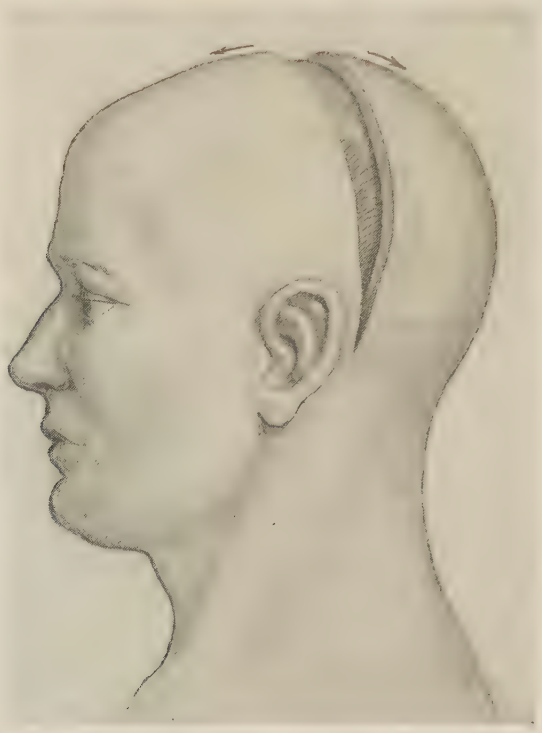


Fig. 525.—Coronal incision for operations upon the skull. The incision is hardly longer than that used in the formation of a large U-shaped flap, but gives access to any portion of the skull.

upon a prompt craniotomy, relief of pressure, and arrest of hemorrhage. An associated fracture of the base of the skull, especially with the escape of cerebrospinal fluid or brain substance, is ominous.

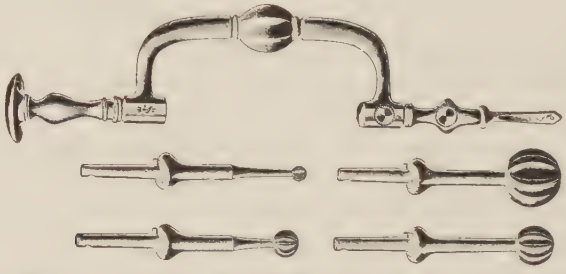


Fig. 526.—Doyen's fraise (for starting the opening) and burrs for perforating the skull. Useful modifications of this instrument have been made by Hudson and Cushing.

General Treatment of Intracranial Hemorrhage.—The patient is placed in a sitting position with an ice-cap to the head; 1/60 gr. of atropin sulphate is given subcutaneously, and 10 c.c. of a 5 per cent. solution of calcium chlorid

intravenously. Two ounces of magnesium sulphate in 4 ounces of warm water are given by enema every two hours while the patient is unconscious. If the hemorrhage is intradural (suggested by diffuse pressure symptoms and the presence of bloody cerebrospinal fluid) spinal punctures are made every six to twelve hours, with the cautious removal of sufficient fluid (10 to 50 c.c.) at each puncture to reduce the spinal pressure to 10 mm. of mercury. The danger of

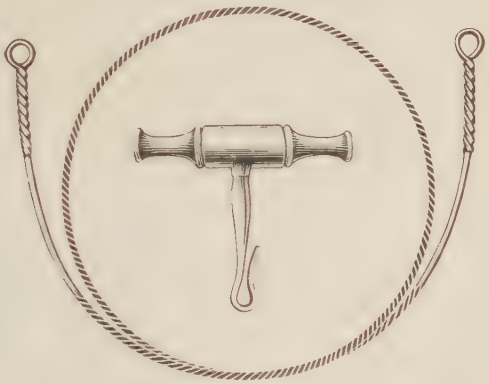


Fig. 527.—Gigli's wire saw and one of the handles. This wire saw may be used to unite openings in the skull formed by a burr.

death from spinal-puncture foraminal hernia in extradural hemorrhage or where the blood is prevented from entering the spinal canal, is to be remembered. If the pressure symptoms increase and the third stage threatens, operation should be done.

Operation is performed on the side of the skull opposite the absent abdominal reflex and lessened thoracic movement, opposite the side of paralysis and highest

Fig. 528.—Schaefer's guide and dural protector for use with the Gigli saw.

temperature, on the side of the dilated pupil and injury or edema of the scalp. The anterior branch of the middle meningeal artery is first exposed; if hemorrhage is not found, then the posterior branch. If again no bleeding is discovered, the opposite side of the skull is explored. The operation should not be deferred until the third stage of bulbar paralysis.

Methods of Controlling Hemorrhage during Operation.—*Hemorrhage from the scalp* is best controlled by free infiltration of the scalp, lateral to the proposed incision, with a 1 : 100,000 adrenalin in 1 or ½ per cent. procain solution, by the lateral pressure of an assistant's hand, or by interlocking sutures lateral to the incision. A tourniquet about the skull is troublesome and unnecessary. *Hemorrhage from the diploë* is controlled by crushing the adjacent bone, or stuffing the opening with a bit of muscle, catgut-wool, or Horsley's wax; from the *dura*, by fine ligatures; from the *pia* or *brain*, by applying free bits of muscle over the bleeding point; from the *bony foramina*, by introducing

catgut, wax, or a sterile wooden peg. Bleeding from the *sinuses* is controlled by packing with catgut or gauze, or by sewing or ligating. Hemorrhage from small vessels may also be well controlled by fine silver clips applied by forceps.

Extradural hemorrhage is characterized by symptoms slower in onset and with a more definite monoplegia or hemiplegia than from intradural hemorrhage. The brain may be so greatly compressed that, after the blood is removed, a great hollow which is very slowly obliterated remains in the brain.

Symptoms: First, *concussion* followed by a lucid interval, when the patient may resume work or be able to walk home or to the hospital; followed by *severe headache*, nausea, vomiting, drowsiness, stupor, coma, increased temperature, monoplegia or hemiplegia, slow pulse, and increased respirations, becoming embarrassed and stertorous. The pupil of the affected side is first contracted, then

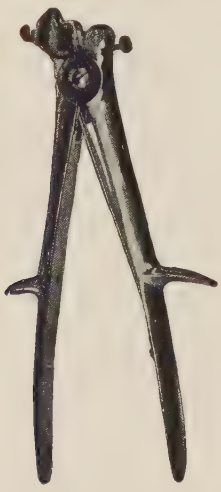


Fig. 529.—Dahlgren's linear cutting rongeur for the skull.

Fig. 530.—Small rongeurs.

dilated. Bilateral wide dilatation of the pupils is ominous. Death often occurs within twenty-four or forty-eight hours unless the pressure is relieved.

Treatment is craniotomy, the ligation of the bleeding artery, and closure. The condition is more amenable to operative treatment, and gives a better prognosis than intradural hemorrhage.

Hemorrhage from the Middle Meningeal Artery.—The clot may spread toward the base and press upon the cavernous sinus, with proptosis and congestion of the eye, paralysis of the oculomotor nerves, and wide dilatation of the pupil. Occasionally, the hemorrhage from the middle meningeal artery does not give rise to symptoms of compression for some days or weeks after the injury (*traumatic apoplexy, external hemorrhagic pachymeningitis*).

Hemorrhage from the internal carotid artery within the skull results from penetrating wounds or fractures of the base, and usually is fatal. Communication between the carotid and cavernous sinus may form with arteriovenous aneurysm, which may be treated by ligation of the internal carotid in the neck.

Injury to venous sinuses may involve the transverse, superior sagittal, and cavernous sinuses. The low pressure within the sinuses favors the spontaneous arrest of bleeding and recovery. Hemorrhage from a sinus is controlled by elevation of the head, packing with catgut or gauze, or by suture or ligation.

Intracranial hemorrhage of the newborn, if untreated, may be followed by spastic paralysis of one or more limbs, on one or both sides of the body, as in Little's disease; by blindness, deafness, varying degrees of mental deficiency, or jacksonian epilepsy. It is most frequent in the first born, in boys, following a prolonged or difficult labor, and especially the delivery of a cyanosed child with a difficult resuscitation. The anterior fontanel is tense, without pulsation, the pulse is slow, there is apathy, difficulty in suckling and swallowing, absence of crying, paralysis of one arm or leg, or of the ocular muscles, inequality of pupils, convulsions or rigidity of the limbs, the thumbs being turned toward the palms. Blood is present in the cerebrospinal fluid of nearly 10 per cent. of newborn babies (Sharpe).

Varieties.—1. *Hemorrhage slight:* The blood is absorbed, with no immediate or secondary symptoms.

2. *Hemorrhage moderate or free,* with increased intracranial pressure, retarded cerebral development, secondary hydrocephalus, spastic paralysis, Little's disease, mental impairment, idiocy. The baby is apathetic, drowsy, quiet, has a feeble cry, fails to nurse, is cyanotic, with rigid extremities, convulsions, twitching of the mouth and face. Facial and ocular palsies may be noted.

3. *Hemorrhage severe,* with marked intracranial pressure tending to paralysis or death. Pallor or cyanosis, stupor, nystagmus, ocular palsy, irregularity of pupils, amaurosis, ptosis, convulsions, and automatic muscular movements occur.

Diagnosis.—The fontanels may be tense and fail to pulsate, but a more reliable test of the increased pressure is the record of the spinal manometer, and the amount of blood found on dural puncture. The spinal fluid rarely is clear.

Treatment.—*Spinal tap,* continued until the pressure falls below 12 mm. of mercury. This is repeated every six to twenty-four hours until the cerebrospinal fluid is clear and the spinal pressure does not exceed 8 mm. of mercury. In the severe types, *cranial decompression* or drainage.

Cerebral contusion or **laceration,** especially of the frontal and parietal lobes may cause the symptoms of *cerebral irritation* (Erichsen). The patient lies on one side, curled in a state of general flexion, is restless, frequently tosses about, but never stretches out or assumes a supine position. The pupils usually are contracted, the eyelids closed, the patient resisting efforts to open them. The skin surface is pale and cool, the pulse slow and feeble. The patient takes little notice of his surroundings and, when disturbed, becomes irritable, muttering, and profane. After one to three weeks the condition may clear, recovery being usual, but the patient may show persistent mental impairment.

In other cases, the cerebral contusion or laceration is associated with the symptoms of concussion, compression, or edema. Cerebral contusion or laceration is to be treated by rest, elimination, and the management of complications.

Cerebral edema follows injury to the brain, the meninges and cortex being infiltrated by serum, giving rise to symptoms suggesting a mild form of compression. The patient is apathetic, disoriented, complains of headache, tender-

ness on percussion over the skull, has diminished reflexes, muscular weakness, and, at times, local or generalized convulsive attacks. The symptoms appear after twenty-four hours from the time of the injury, and may persist for days or weeks.

Treatment.—The patient should be kept at *rest* in a darkened room for at least three weeks. The head should be elevated, and free elimination (*osmotic treatment*) used. Epsom-salt solution is given by mouth and rectum and, if the symptoms are alarming, hypertonic salt solution intravenously.

Complications of Cranial Injuries.—1. **Early:** Include cerebral edema, meningitis, pachymeningitis, leptomeningitis, which may be basilar or of the convexity. Later fungus cerebri or hernia cerebri may occur.

2. **Late:** Sequelæ, slight or severe, follow 50 per cent. of fractures of the skull, the incidence being increased by previous alcoholism, old age, or insufficient care and treatment. Remote symptoms include: (a) *Cephalalgia*, often associated with tenderness, usually referred to the vertex, the frontal, or occipital regions. When due to osteosclerosis or meningeal adhesions, it may be relieved by drilling or trephining. Painful scars or adhesions between the scalp and the cranium may be excised or freed.

(b) *Vertigo* occurs in 22 per cent. of the patients after fracture of the skull, and may be associated with vomiting or susceptibility to sunstroke.

(c) *Mental changes* vary from mental irritability, insomnia, loss of initiative, inability for mental exertion, to alcoholism, melancholia, and suicide. *Traumatic insanity* follows in 10 per cent., especially after injury over the left prefrontal or parietal region. If there was no previous predisposition to a psychosis, operative treatment should be considered. *Motor aphasia* follows injury to Broca's gyrus. *Amnesia* in slight degree occurs in 35 per cent. There may be loss of memory of the accident and of the few following days, which is usual; loss of memory of life previous to the injury, which is unusual; or loss of memory for events subsequent to the injury, which is common.

(d) *Special nerve symptoms* include anosmia, inequality of pupils, accommodative asthenopia, nystagmus, amaurosis from optic atrophy, facial paralysis, deafness (12 per cent.). Increased knee-jerk and slow pulse may occur. *Glycosuria* of a temporary character is common; permanent glycosuria is very rare, and usually follows injuries to the back of the head. *Paraplegia* may be primary or secondary from a scar, cyst, or sclerosis of the brain.

(e) *Traumatic epilepsy* occurs after 7 per cent. of fractures of the skull. It is usually idiopathic, one-third being jacksonian. In jacksonian traumatic epilepsy the convulsions precede loss of consciousness and spread over the body, the muscles first convulsed remaining paralyzed for some time after each convulsion. About 75 per cent. are cured or improved by operation, which is indicated if there is a definite injury, scar, cranial depression, or defect of less than two years' duration, with the absence of a family history of epilepsy or insanity (Crest English). The *operation* consists in exposing the brain, freeing it from adhesions, removing clots, cysts, tumor, bone, scars, or foreign bodies and, if no gross exciting lesion is found, the cortical area is localized by electric tests, and the area presiding over the muscles which initiate the convulsions excised.

Abscess is much more common in the cerebrum than cerebellum, is usually single, contains from a few drops to several ounces of pus and, perhaps, also a slough of brain matter. The pus is greenish yellow or brown, may be odorless or fetid, and the pia-arachnoid is usually inflamed over the abscess cavity. The abscess may be cerebral or cerebellar.

Etiology.—1. *Otitis media* is the most common cause of brain abscess. The abscess from this cause is usually single and lies in the centrum ovale of the temporosphenoidal lobe or in the cerebellum. From the middle ear the infection may enter the brain: (a) Through air-cells of mastoid (*Gradenigo's syndrome*). (b) By labyrinth or along the course of seventh or eighth nerve to internal auditory meatus, or by the ductus or saccus endolymphaticus or the aquæductus cochleæ. (c) Through the tegmen tympani, the inner table of the skull, or by thrombosis of the petrosal or cavernous sinuses. Ten per cent. occur under the age of ten, 1 per cent. under five, 60 per cent. between ten and thirty.

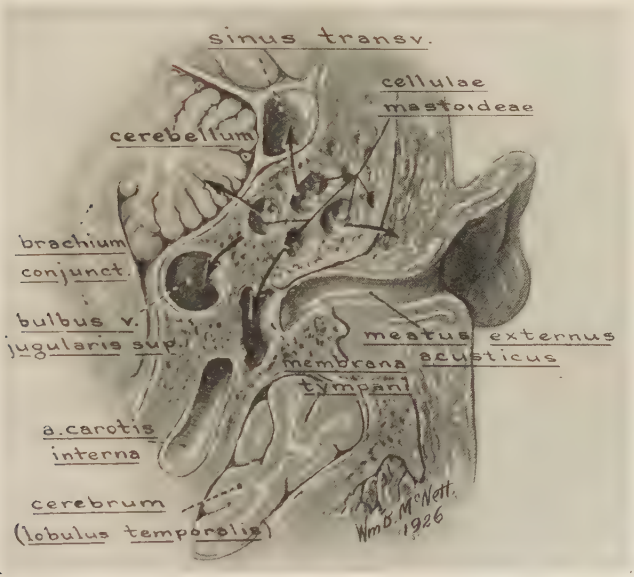


Fig. 531.—Methods of extension of the infection in otitis media.

2. *Infections of the nasal passages or sinuses.*

3. *Injury or infection of the skull*, compound fractures, bullets and other foreign bodies, osteomyelitis, syphilis, or tuberculosis of the skull.

4. *Metastatic infection* in bronchiectasis and pyemia.

5. *Infection from scalp and face* spreading through the bones by lymphatics, veins, arteries, or nerves.

Symptoms.—*Three Stages:* (1) *Initiatory*, with evidence of meningitis and encephalitis. (2) *Quiescent*, with evidence of intracranial pressure and localization, resembling that of brain tumor. *Fully formed abscess:* The patient lies in semistupor, the face is placid and expressionless, the cerebration slow, the patient answering questions after a delay slowly, briefly, but correctly in monosyllables; the temperature may be persistently normal or subnormal, the pulse is

slow (40 to 60); there is anorexia, constipation, and at times vomiting. Rigor and temperature elevation now indicate complication such as sinus phlebitis. (3) *Terminal*, with symptoms of increasing pressure as delirium, stupor, coma, stertorous breathing, meningismus, dilated pupils, rapid pulse, paralysis, often associated with diffuse encephalitis. The pus may rupture into the ventricles with sudden exacerbation of symptoms, the pupils becoming widely dilated, the face livid; the respirations rapid, shallow, and stertorous; the pulse rises to 120 or more; the temperature to 105° F. or more; muscular twitchings, convulsive and tetanic seizures occur, succeeded by coma and death within a few hours.

In cerebral abscess leukocytosis is absent or moderate, average 16,000. Spinal-fluid cell-count is normal except with meningitis or encephalitis. Optic neuritis occurs in 30 per cent. of the patients.

Localization.—1. *Frontal Lobe:* The abscess may be (a) *symptomless* or "silent"; or cause (b) *apraxia*, loss of purposeful co-ordinate movement; (c) *motor aphasia*, loss of motor speech, from involvement of Broca's area in posterior third of left (in the right-handed) inferior frontal gyrus; (d) *agraphia*, loss of writing ability, from involvement of writing center in posterior portion of the middle frontal gyrus. (e) *Papilledema:* If hemolateral, it indicates pressure above; contralateral, pressure below; bilateral, pressure at the optic commissure. The papilledema must be differentiated from that occurring from disease of the nasal sinuses.

2. *Parietal Lobe.—Paralysis of the face and limbs* of the opposite side of the body occurs from involvement of motor areas in the precentral convolution. Convulsions indicate that the cortex is irritated.

If the paralysis involves first the face, then the arm, and then the leg, the pressure is probably upon the cortex; if first the leg, then the arm, then the face, the pressure is on the internal capsule.

3. *Occipital lobe* is rarely involved. The abscess may be shown by ventriculogram. Bárány's tests show the presence of a lesion, but do not give the area of localization.

Involvement of the occipital lobe produces visual disturbance; if of the cuneus, right or left hemianopia.

4. *Temporal lobe* is most often involved. The abscess usually following middle-ear disease of the same side. If large, the abscess may press on the motor cortex, the fibers of the internal capsule, or the individual cranial nerves. The most important localizing symptoms are: (1) Naming aphasia or loss of word memory, from involvement of left (in right-handed persons) superior temporal gyrus. (2) Auditory aphasia from involvement of first superior temporal gyrus. (3) Hemianopic indentation of both visual fields, from involvement of fibers of Gratiolet. These fibers pass from the visual center in cuneus to the primary visual centers in corpora quadrigemina, and are compressed between the cortex of temporal lobe and inferior cornu of lateral ventricle.

5. *Cerebellar abscess* is characterized by nystagmus, vertigo, incoördination, ataxia, optic neuritis, blindness, embarrassed or Cheyne-Stokes breathing. The patient tends to fall toward the side opposite the abscess; there may be retraction of the head and neck; and arrest of respiration may occur during anesthesia.

Mortality 85 per cent., being highest in the frontal, less in the cerebellar, least in the temporal abscess. Death frequently occurs from encephalitis.

Operation.—1. Local anesthesia, all general anesthetics to be avoided.

2. Area of skull, 2 or 3 cm. in diameter, exposed by vertical incision.

3. One- or 2-cm. incision through bone by large Doyen or Hudson burr. Mallet and chisel are not to be used.

4. The abscess is localized by large exploratory needle. The pus may be so thick as to clog a small needle.

5. Free incision, into abscess cavity, or uncapping of abscess (King) by a two-stage operation. A short decalcified bone-tube or a rubber tube-drain may be necessary.

6. Manipulation, probing, injection, and irrigation are to be avoided.

7. *Macewen's powder* (boric acid, 2 parts; iodoform, 1 part) applied with voluminous gauze dressing to the dura, the wound to be left freely open.

8. It is desirable to keep the patient in bed for months after healing has occurred.

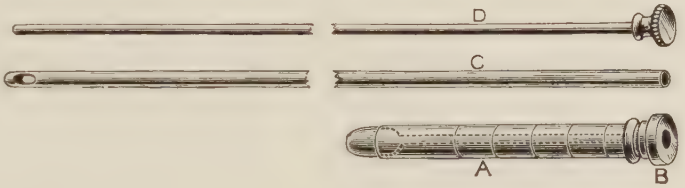


Fig. 532.—Frazier's exploring trocar for the brain, used for the location and evacuation of a cerebral abscess. With drainage cannula *C* is used for exploratory purposes. The mandrin *D* is used to clear the cannula. After location of the abscess, *A* and *B* assembled are passed over *C*, which is withdrawn, and left in place as a drainage-tube.

Death may result from the use of ether or nitrous-oxid anesthetic; or from lumbar puncture with cerebral displacement or hernia occurring through the foramen magnum.

Sinus-phlebitis.—Infective thrombosis of the cerebral sinuses.

Etiology.—The *lateral sinus* is most frequently infected from middle-ear disease; the *cavernous sinus* may be affected from the *accessory sinuses* of the nose; from the face or orbit or by extension from one of the other dural sinuses. The *superior sagittal sinus* is rarely involved, infection occurring from erysipelas, cellulitis, osteomyelitis, or infection of the scalp, face, nose, or cranial bones.

Pathology.—In the infected sinus a soft adherent thrombus forms, the center of which liquefies into pus; the process may spread, and particles be carried as septic emboli to various parts of the body, causing multiple secondary abscesses and pyemia.

Meningitis, brain abscess, and osteomyelitis are frequently associated with sinus thrombosis.

Symptoms.—Following a pre-existent middle-ear disease, infected wound, or other septic focus about the head, there is violent cephalalgia followed by chill, rigor, sweats, and fever with a remittent temperature reaching 103° to 106° F.

The pulse, at first full and slow, becomes rapid and thready; there is mental irritability, followed by dulness, stupor, or delirium. During the rigor, dyspnea and cyanosis may be marked.

Special Symptoms: 1. *Transverse (lateral) sinus thrombosis*, the discharge from the ear stops. There often is tenderness, cord-like induration, and even abscess of the neck, from involvement of the jugular vein; percussion tenderness over the mastoid and, at times, edema and congestion on the side of the face. Rarely, the inflammation spreads to the nerves passing through the jugular foramen, with hoarseness, dysphagia, dyspnea, and slow pulse.

2. *Cavernous sinus thrombosis* is usually secondary to involvement of the other sinuses, as when after sigmoid sinus thrombosis the infection spreads through the superior and inferior petrosal sinuses. It follows infections about the nares and upper lip where traumatism, the absence of subcutaneous fat, active muscular action, and inability of the veins of this area to collapse aid in spreading the infection. The thrombosis may also be secondary to peritonsillar abscess, nasal infections, or curettage of tooth sockets. The causal agent is usually the staphylococcus.

Fig. 533.—Proptosis and edema of the eyelid from cavernous sinus thrombosis beginning as an extension from a chronic purulent otitis media of the opposite side with secondary involvement of the right cavernous sinus and sigmoid sinus with final abscess in the frontal lobe and death. (DaCosta, "Modern Surgery.")

Symptoms include orbital congestion, exophthalmos, proptosis, edema of the eyelids, chemosis, choked disk, retinal hemorrhages, ocular paralysis with hyperesthesia of first division of the fifth nerve, and occasionally herpes. Epistaxis may follow the blocking of the ethmoidal vein which drains into the cavernous sinus. The opposite sinus is often involved by extension through the intercavernous sinuses.

3. *Superior sagittal* or *longitudinal sinus thrombosis* follows gunshot and other wounds, is associated with edema and tenderness of the overlying scalp, enlarged veins, epistaxis, weakness and convulsions involving one or both legs; loss of cortical sensation, Babinski's response, and ankle-clonus.

Prognosis.—*Septic cavernous sinus thrombosis* is usually fatal, although the patient may live several weeks. The mortality of transverse sinus or sagittal sinus thrombosis is about 40 per cent.

Treatment.—*Transverse sinus:* (1) Radical mastoid operation to correct the infection of the middle ear. (2) Exposure of the sigmoid sinus. The *diagnosis* is confirmed by palpation or the introduction of a hypodermic needle into the sinus or by finding thrombosis of the emissary vein. (3) Free incision in the thrombosed portion of the sinus, without irrigation or curettage. (4) The wound is left freely open and a copious, moist iodoform-gauze dressing applied.

If the jugular vein is thrombosed and inflamed, it should be incised and drained with the least possible manipulation. Irrigation, ligation of the jugular vein in

Fig. 534.—Division of the dura exposing dural origin of large meningioma (endothelioma) invading the parietal lobe.

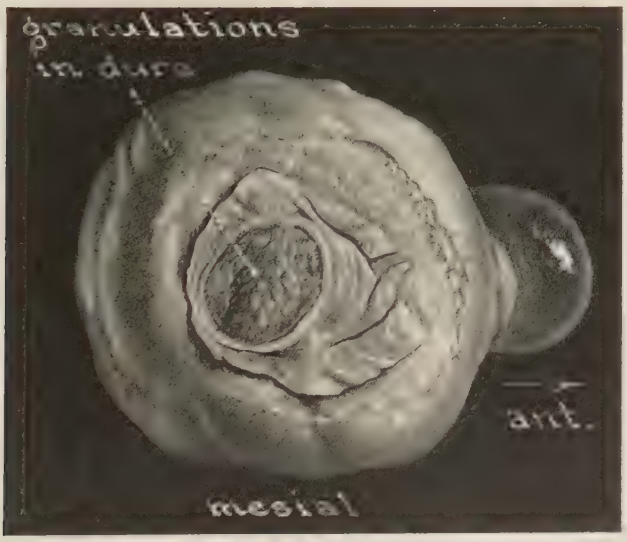


Fig. 535.—Large meningioma removed from parietal lobe. Tumor was well encapsulated and had produced almost complete hemiplegia. Easily enucleated by traction upon the adherent dura, and recovery with almost complete return of function followed.

the neck, curettage, and attempts to remove the thrombus, so often advocated, greatly increase the danger from septic embolism.

The *sagittal sinus* may be exposed by trephine above the torcular, freely incised and drained.

Secondary complications include cerebral or cerebellar abscess, purulent meningitis, cellulitis, pyemic pulmonary abscess, or pulmonary gangrene.

Tumors of the brain may involve the brain primarily, secondarily, or by contiguity from the skull or membranes.

Varieties and Location.—Of the newgrowths involving the brain 55 per cent. are gliomas, 14 per cent. endotheliomas, 8 per cent. sarcomas, 6 per cent. carcinomas, 5 per cent. tuberculomas, 5 per cent. fibromas, 2 per cent. cysts, 1 per

Fig. 536.—Fibroma of cerebellopontile angle showing pressure upon fifth, sixth, seventh, ninth, and tenth cranial nerves.

cent. ventricular papillomas, 1 per cent. cholesteatomas, 1 per cent. pituitary tumors, and 1½ per cent. pineal tumors. They are found chiefly in the frontal lobe, the cerebellum, the cerebellopontile angle, and the pituitary.

Gliomas are divided into astrocytomas or adult glioma, the gliosarcoma or anaplastic glioma, and the neuro-epithelioma or embryonal glioma. In early life these tumors are found in the brain, eye, and ganglia. They are not easily differentiated from the adjacent brain, being slightly more vascular, bluish or more opaque than the cerebral substance, and causing some flattening of the overlying convolutions. Rarely they are multiple.

Etiology.—Males are affected nearly twice as frequently as females; 80 per

Large meningioma enucleated from parietal lobe of the brain under local anesthesia.

cent. occur before the age of forty, 28 per cent. below the age of twenty. Heredity has no apparent influence. A previous history of traumatism is often given.

Symptoms.—The cardinal symptoms of brain tumor are: 1. *Headache*, which may be localized and associated with tenderness on percussion.

2. *Cerebral vomiting*, present in one-third of the cases, is not related to the taking of the food, is projectile in type, and without retching or nausea.

3. *Optic neuritis*, varying from papilledema with limitation of the color field for blue, to complete blindness, usually more marked on the side of the tumor.

4. *Paralysis.*—A monoplegia or partial hemiplegia.

Other symptoms include *vertigo*, *ataxia* (especially in cerebellar tumors), and convulsions, particularly where the motor cortex is involved; mental deterioration, especially in frontal-lobe tumors. Acromegaly or adiposity occur with pituitary growths.

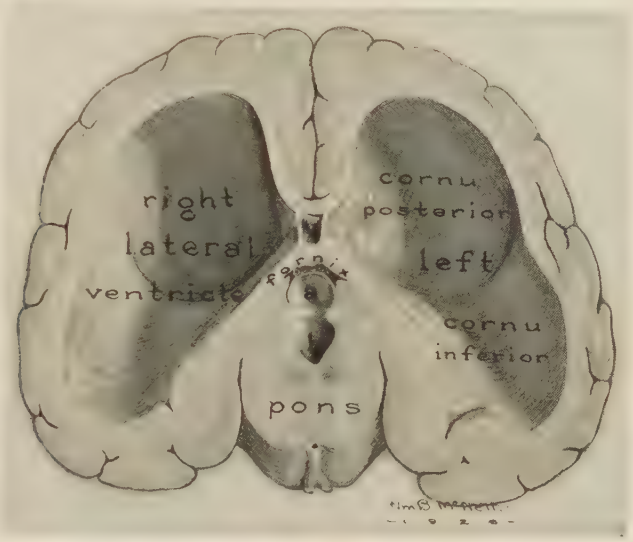


Fig. 537.—With marked distention of the ventricles from pressure of cerebellar tumor, aspiration of the distended ventricles may save the life of the patient.

A tumor of the motor cortex tends to produce jacksonian convulsions, followed by palsy, motor and sensory aphasia, and local tenderness on percussion. A subcortical tumor produces paralysis with loss of motion in the opposite side of the body, and possibly later convulsions when the growth involves the cortex. From a tumor involving the internal capsule there is wide-spread early paralysis without spasms.

Diagnosis.—1. *Headache*, which is due to the dural tension or meningeal irritation, is localized and often associated with tenderness on percussion, but must be distinguished from toxic, renal, and reflex headache.

2. *Vomiting* is sudden, projectile, without nausea or relation to food, but is aggravated by movement, thus differing from headaches of abdominal origin.

3. *Optic neuritis* includes: (a) Choked disk, usually more marked on the side of the tumor. (b) Neuritis and optic atrophy (cyanotic) suggest disease at the base of the brain. (c) Blindness results from continued marked pressure and, if not of long duration, may be relieved by a decompression operation.

4. *Paralysis.*—Tumors involving the motor cortex cause jacksonian epilepsy, preceded by an aura and followed as the tumor grows by a localized paralysis. Tumors of the *cerebellopontile angle* produce cerebellar symptoms with irritation

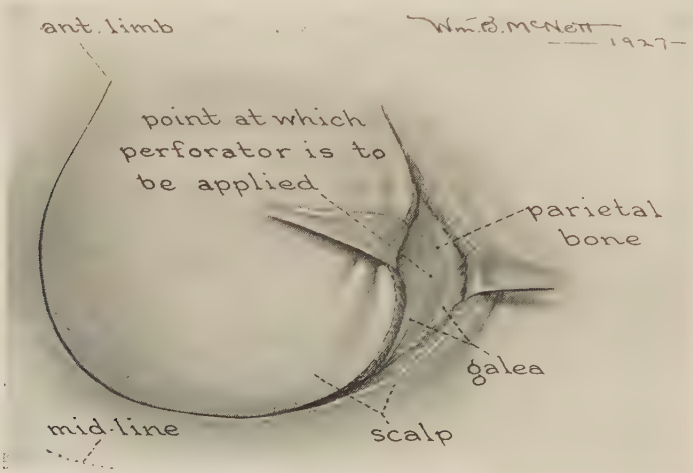


Fig. 538.—Osteoplastic craniotomy: Division of galea and exposure of the skull.

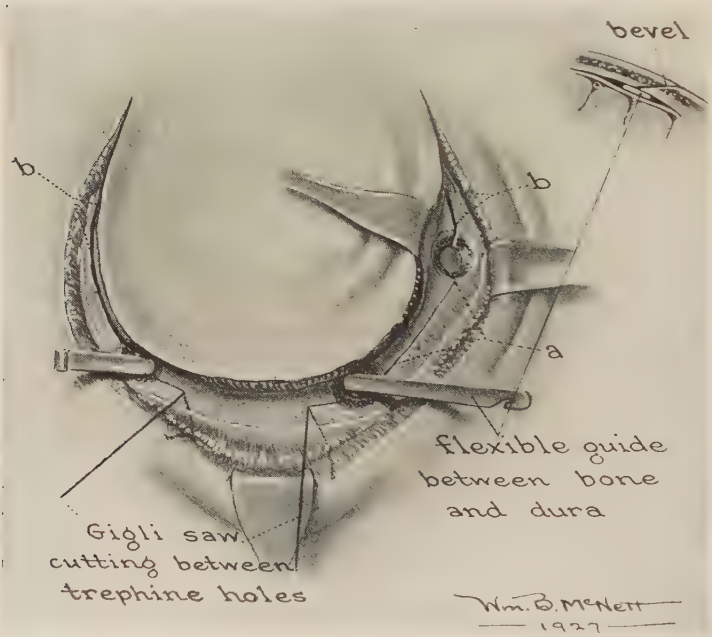


Fig. 539.—Osteoplastic craniotomy: U-shaped flap of scalp has been formed, the vessels controlled, drill holes have been made through the skull which are being united by a bevelled cut with a Gigli saw, the underlying dura is protected from the saw by a flexible metal guide.

or paralysis of the cranial nerves, from the fifth to the twelfth; especially the facial nerve, with facial weakness or paralysis, and the eighth nerve with tinnitus, inability to recognize high-pitched notes (Galton's whistle), or unilateral deafness.

The progressive enlargement of a tumor may be followed by stupor, coma, and death. The more rapid the growth, the more serious the symptoms. Hemorrhage into the tumor may produce sudden dangerous increase in symptoms.

Differential Diagnosis.—*Gliomas* are infiltrative, usually occur in the young, grow first slowly and then rapidly, and are subject to hemorrhages with sudden increase in symptoms.

Endotheliomas spring from the dura mater, are encapsulated, non-infiltrating, removable, and often are situated at the base of the brain or in the spinal cord.

Sarcomas usually develop between puberty and middle life, grow slowly, are encapsulated, displacing rather than infiltrating adjacent tissue, and offer greater possibilities of extirpation than gliomas.

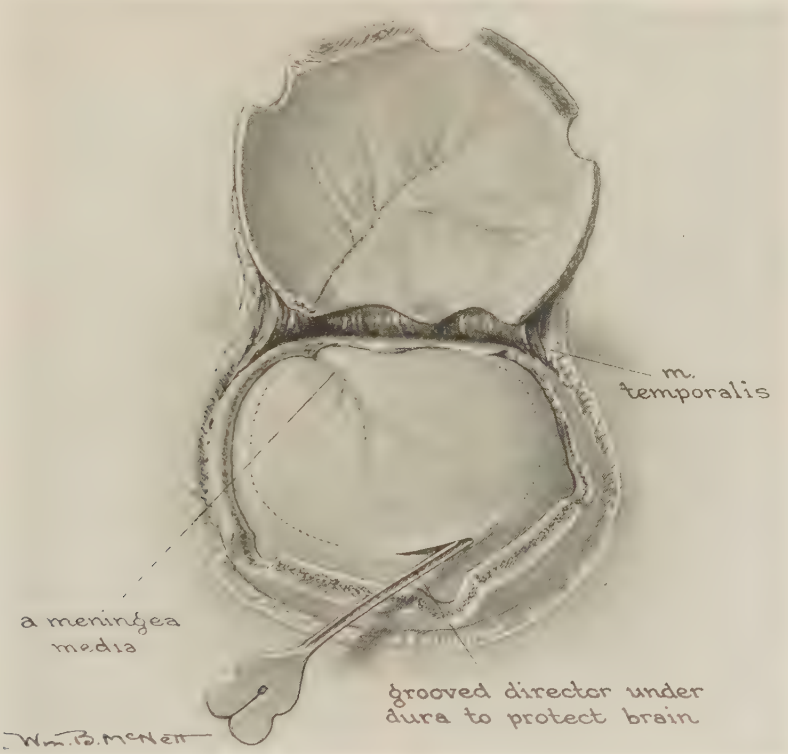


Fig. 540.—Craniotomy with osteoplastic flap. Position of dura on a grooved director.

Fibromas grow slowly, usually occur at the base of the brain or in the cord, and occasionally the symptoms are entirely relieved by a simple decompression operation, without removal of the tumor.

Syphilitic gummas form about 2 per cent. of the new growths of the brain, and involve the cortex or dura mater. They usually occur between the ages of forty and sixty from acquired syphilis, and often are associated with severe nocturnal pain. A negative Wassermann, or lack of improvement under antisyphilitic treatment, does not exclude the presence of a gumma.

Tuberculomas occur chiefly in children and in the adolescent. Tuberculous

masses may be single or multiple, usually involve the cortex of the cerebellum, show irregular spasmodic growth, and may be associated with a basilar tuberculous meningitis.

Prognosis.—Tumors of the brain cause 1 per cent. of all deaths. The *malignant* and *infiltrative tumors* are especially found on the cortex, and convexity; *benign tumors* about the base, in the cerebellopontile angle, the pituitary body, and spinal cord. From a cerebral tumor, death may occur suddenly from hemorrhage, acute edema, acute distention of the ventricles, or involvement of vital centers. Syphilitic or tuberculous growths often recur. The infiltrative gliomas are usually fatal, the average duration of life being about ten months. Endotheliomas, which are encapsulated, but recur after excision, give an average duration of life of twenty months. Sarcomas give a duration of life of about five months. Recovery occurs in 10 per cent. or less of brain tumors despite operation. The operative mortality is 20 per cent.

Fig. 541.—Exposure of glioma of the brain.

The complications of cerebral tumor are due to pressure, hemorrhage from the growth, inflammation, edema and thrombosis, ventricular hydrops (which is common), and involvement of the spinal cord.

Treatment.—Operative extirpation or decompression. Even tuberculous tumors are seldom permanently relieved without operation, and gummas may require excision.

1. *Palliative Treatment.*—(a) *Cerebral Decompression:* Symptoms produced by pressure from an unlocated or irremovable tumor of the brain are often relieved by decompression. Paralysis may largely disappear, vision return, and vomiting cease. If the tumor is benign or of very slow growth, the patient may be relieved for years by the decompression. It is also valuable as a first-stage operation, the tumor tending to approach the surface near the defect pro-

duced in the skull, where it may be accessible and removable at a second operation. Decompression may be subtemporal for cerebral growths, or suboccipital for subtentorial growths. For the *subtemporal decompression* a nearly vertical incision is made over the fibers of the upper part of the temporal muscle, the fibers separated and retracted, the skull perforated, and the bone freely rongeured away, until a round or oval defect (5 to 8 cm. in diameter) is produced. Radiating incisions are made through the dura from the center of the opening, the separated muscle-fibers sutured together, and the scalp carefully closed. The overlying muscle prevents excessive protrusion and herniation of brain through the opening, a cause of marked disfigurement and of serious damage to the brain. In *suboccipital decompression* a curved or a *Cushing cross-bow incision* is made, the scalp and muscles below the superior nuchal line turned back, and the occipital bone opened on both sides of the median line and rongeured toward the middle line, exposing the straight sinus which is doubly ligated and

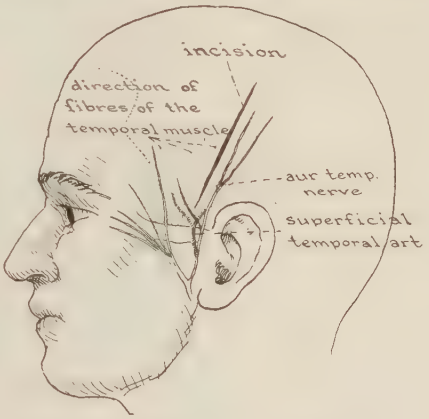


Fig. 542.—Subtemporal decompression, line of incision.

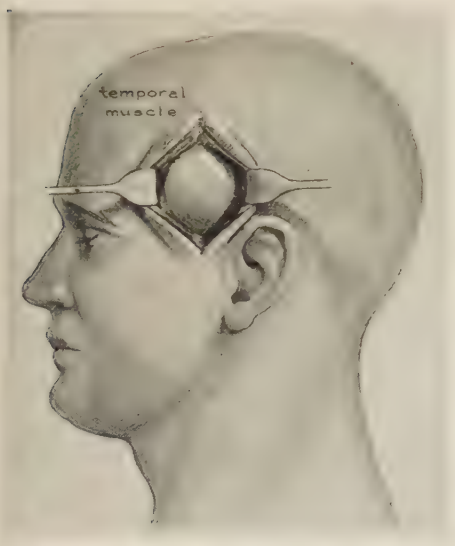


Fig. 543.—Line of incision and separation of fibers of temporal muscle for subtemporal decompression of the skull.

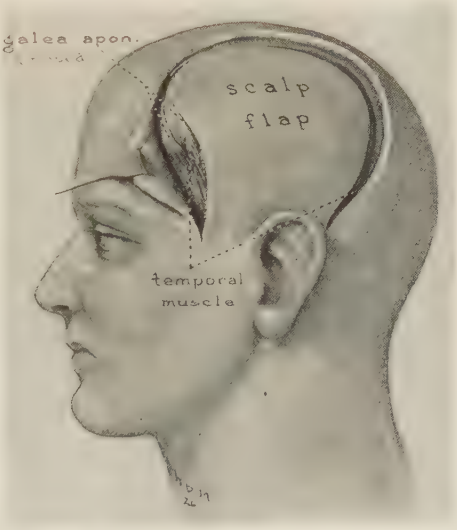


Fig. 544.—Craniotomy: Formation of flap of scalp. To avoid the upper branches of the facial nerve the anterior limb of the incision should not extend below the hair line.

divided. The dura is opened by radiating incisions, and the muscles and overlying scalp are finally sutured over the defect.

(b) *Ventricular Tap:* With a tumor of the cerebellum or base of the brain, a

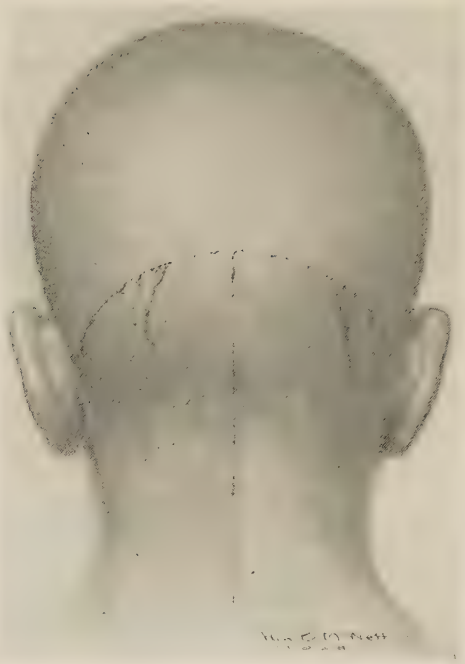


Fig. 545.—Subtentorial craniotomy: The cross-bow skin incision of Cushing.

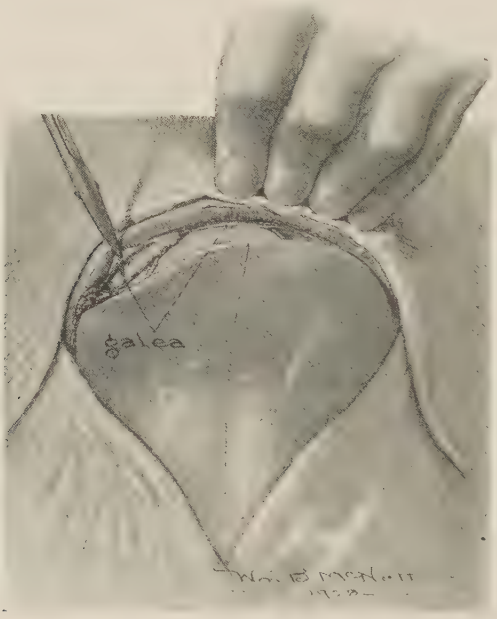


Fig. 546.—Subtentorial craniotomy: Skin muscles and galea have been partially divided.

patient may suddenly collapse during anesthesia, or at other times from the intracranial pressure due to the distention of the lateral ventricles by fluid. Aspiration of the lateral ventricles enables such a patient to be resuscitated, and the operation to be completed. It may also prolong the patient's life.

(c) *Spinal or Lumbar Puncture:* In increased intracranial pressure due to cerebral tumor or abscess, spinal puncture occasionally gives relief by removing cerebrospinal fluid, but this involves the danger of sudden death from herniation of the base of the brain through the foramen magnum.

2. *Medicinal Treatment.*—Temporary improvement with or without treatment often occurs in cerebral tumors. The fact that symptoms improve after

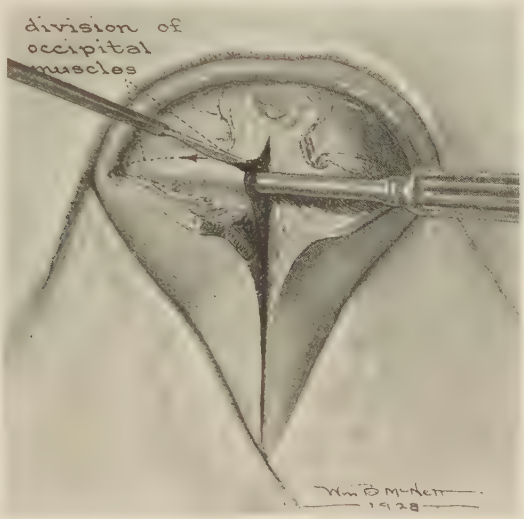


Fig. 547.—Subtentorial craniotomy: The skin has been divided, the deep muscles are being divided and separated.

the administration of iodid of potassium does not prove that the growth is a gumma. Gummas are rarely completely relieved by medicinal treatment, yet large doses of iodids, 10 to 40 gm. (150 to 600 gr.) daily, should be tried.

3. *Operation. Craniotomy* is used for the removal or decompression of intracranial tumors.

Craniotomy.—The skull may be opened under local or general anesthesia through a straight or curved incision of the scalp. A coronal incision from mastoid to mastoid gives access to any part of the skull. The skull is perforated by a large burr and sufficient bone removed (a) in small pieces by rongeurs; or (b) a section of bone (which may remain attached to the overlying scalp forming an *osteoplastic flap*) raised, to be replaced at the completion of the operation. In the latter case the bone is divided between drill holes by a chisel, a narrow-bladed rongeur, a power-driven linear osteotome, circular saw, Hey's saw, a Gigli saw, or by fracturing the bone. Formerly a trephine was used. The formation of an osteoplastic flap is unnecessary, as a large section of the skull completely detached at operation, if replaced, readily unites to the adjacent tissues. The dura is opened after occluding the vessels by fine ligatures or silver clips. At the completion of the craniotomy, unless a decompression or drainage is desired, the dura is closed, the section of bone replaced, and the galea and scalp accurately united, usually by interrupted sutures.

Craniotomy is indicated for infection, accessible intracranial foreign bodies, hyperpressure, irreducible cerebral hernia, lesion of the occipital or frontal region with visual disturbance, and recurrent epilepsy unimproved by prolonged rest.

Trephine syndrome from operative defects in the skull includes a sensation

of emptiness on the trephined side; unpleasant sensation with vertigo and nausea on stooping, lowering the head, or on coughing; intolerance of external vibrations, and disturbance of equilibrium.

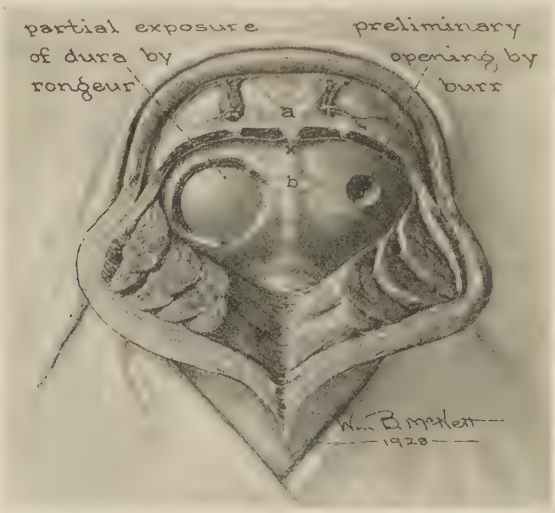


Fig. 548.—Subtentorial craniotomy: The occipital bone is drilled on each side of the midline by a large burr, and the bone removed by a rongeur.

Operation.—(a) Local anesthesia by 1 per cent. procain-adrenalin; (b) removal by chisel (from uninvolved portion of the skull) of a free transplant of pericranium and attached scales of bone, which are flattened by a mallet; (c) fitting of the free pericranial osteoplastic flap into the defect, the bone being

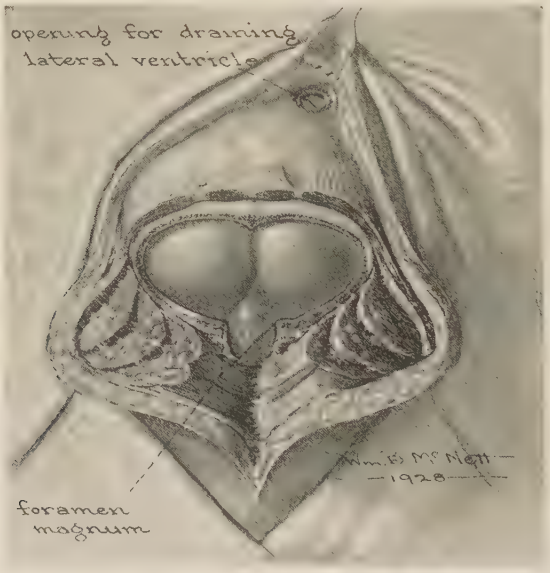


Fig. 549.—Subtentorial craniotomy: The bone has been removed, opening the foramen magnum. An opening has been made above the transverse sinus for drainage of the lateral ventricle.

outward, and (d) closure of the overlying scalp after complete hemostasis. Cartilage, homologous living, or an alien dead bone (boiled bone) graft is also used to fill the defect. Dead alien bone may later undergo absorption. The dura is liberated around the circumference of the defect. The bone implant is fitted by cutting with a saw, by rongeuring and filing.

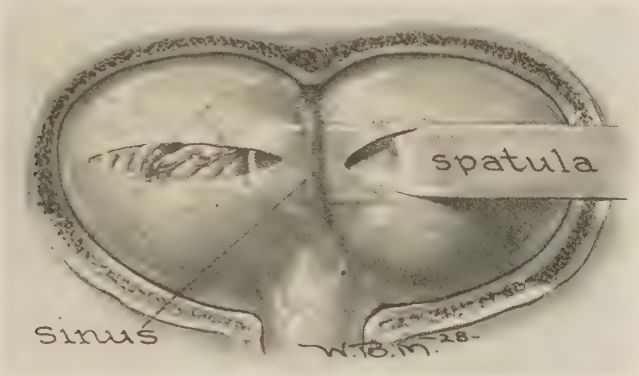


Fig. 550.—Subtentorial craniotomy: The dura has been incised on either side of the midline and the straight sinus located.

Hernia Cerebri.—Cerebral hernia is a protrusion of brain through an acquired opening in the skull, the result of operation, injury, or disease. There is increased intracranial tension, usually from a tumor or inflammatory effusion within the skull. The mass pulsates at first but, as it increases in size, pulsation ceases and strangulation and necrosis may follow.

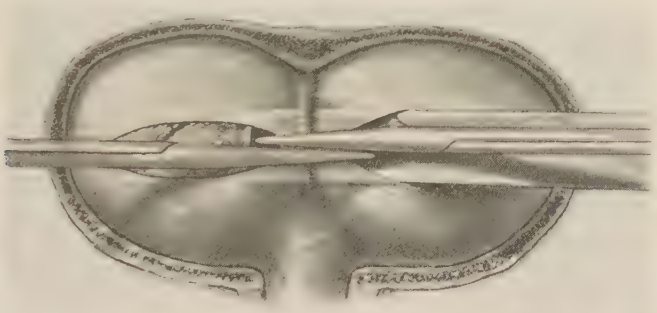


Fig. 551.—Subtentorial craniotomy: The sinus is doubly clamped preliminary to ligation or suture.

Treatment may be ineffective on account of an ineradicable type of tumor or other underlying disease. Treatment consists of reducing intracranial pressure by: (a) *Spinal puncture* (if no contraindication); (b) *aspiration of ventricles;* (c) *osmotic tap* by saline purgation, or intravenous injection of hypertonic salt solution; or (d) *removal of* the underlying *brain tumor,* or evacuation of brain abscess. Locally, sterile rubber tissue or silver-foil is applied, and covered by compresses wet with salt solution. Manipulation and frequent dressings

should be avoided. The mass may be covered by a pedicled flap of scalp or adjacent muscle. When aseptic healing has occurred, the defect in the skull may be closed by a transplant of pericranium with attached bone, chiseled from the outer layer of the skull, or by a transplant of fascia.

Fungus cerebri is a sloughing, fungating mass, protruding through an acquired opening in the skull. It consists of edematous granulation tissue derived from the neuroglia, but not brain substance. The mass may reach the size of a small egg, and contain one or more abscesses or fragments of bone. It is bluish, purplish, soft and pliable at the margins of the bony opening, and may

Fig. 552.—Subtentorial craniotomy: Exposure of cystic tumor of left cerebellar hemisphere.

pulsate unless it contains an abscess. It may follow infection of a simple hernia cerebri, or more frequently results from a compound fracture with exposure of the brain substance to infection, or the presence of foreign bodies.

Prognosis.—Usually is fatal.

Treatment.—Evacuation of abscesses, removal of foreign bodies, and the antiseptic treatment of the wound, such as the application of 5 per cent. dichloramin-T or a 5 per cent. solution of permanganate of potassium. Resection of the protruding mass may be necessary.

CHAPTER XXXIV

THE CRANIAL NERVES

Irritation or paralysis of cranial nerves result from compression, contusion, laceration, division, edema, or inflammation: (1) *Directly from injury*, as fracture of the skull, in which case the symptoms come on immediately; (2) *from secondary edema*, causing compression and symptoms several hours after the injury; or (3) *from inflammation*, such as meningitis, with symptoms appearing two or three days after the injury. (4) Pressure may also occur *from hemorrhage* or *newgrowths* in the skull. When the trunk of the nerve is involved, the paralysis is on the side of the lesion and of the lower-neuron type. If the cortical center or upper axon is affected, the paralysis is on the side opposite to the lesion and of the upper-neuron type.

Olfactory Nerve.—Branches of the olfactory nerve may be involved as they pass through the cribriform plate of the ethmoid, in fracture of the anterior fossa of the skull, or from hemorrhage, contusion, tumor, or meningitis of the anterior fossa.

Alterations in the sense of smell occur from lesions of olfactory fibers at any point, from the nasal mucosa to the centers in hippocampus and uncinate gyrus.

Symptoms.—(1) *Anosmia:* Loss of the sense of smell with corresponding impairment of the sense of taste. Tests should be made with essential oils, such as clove or peppermint. Ammonia also stimulates the fifth nerve. (2) *Parosmia:* Perversion of the sense of smell. This is rare, but occurs from injury or from tumors of the hippocampus. It is common in hysteria, insanity, or during the aura of epilepsy. (3) *Hyperosmia:* Increased sensitiveness to odor; occurs chiefly in hysteria.

Optic Nerve.—1. **In the orbit or region of cavernous sinus** the optic nerve may be: (a) *Divided* by a bullet, fragment of bone, or other object, with immediate permanent unilateral blindness; or (b) *pressed upon* by an effusion of blood, serum, pus, or by tumor, gumma, or aneurysm, with secondary transient or complete blindness.

2. **Involvement at the optic chiasm** may cause heteronymous hemianopia; if from pituitary tumors, bitemporal hemianopia from pressure on the fibers that supply the nasal half of each retina. The hemianopia may progress to complete blindness. The chiasm may also be involved in cerebral syphilis, and rarely in hydrocephalus.

3. **Optic Tracts.**—Lesions of the visual paths between the optic chiasm and the cerebral cortex produce lateral hemianopia.

In lesions from the optic tract to the lateral geniculate body, the pupil reflex is absent. If in the posterior portion of the internal capsule, there is usually hemianesthesia or hemiplegia, while the pupil reflex is normal. If of the optic radiation, there is partial hemianopia with normal pupillary reflex. If

of the cuneus and lingual gyrus, there is limited hemianopia and normal pupillary reflex. If bilateral, there is total blindness. Lesions of the angular gyrus lead to crossed amblyopia concentric diminution of the visual fields (greater on the side opposite the lesion), and mind blindness, while the pupil reflex is normal.

Optic neuritis follows increased intracranial pressure from tumors of the brain, cerebral abscess, meningitis, and traumatic effusions within the skull. It varies from papilledema, with distended tortuous veins of the retina and small arteries, to optic neuritis and secondary optic atrophy. The blindness may disappear on relief from pressure, if not of too long duration. Unfortunately, intervention often is too late to restore vision.

Third or **oculomotor nerve** arises from separate nuclei in the cerebral aqueduct (Sylvius), and emerges on the inner side of the crus just in front of the pons. The cortical center lies close to the center for the face.

The **superior ramus** supplies: (1) The *levator palpebræ superioris* (ptosis or drooping of upper eyelid) and (2) the *rectus superior* (downward rotation of the eye with diplopia).

The **inferior ramus** supplies: (1) The *rectus medialis* and *rectus inferior* and *obliquus inferior* (lateral strabismus); (2) the *constrictor of the iris* (dilatation of the pupils, mydriasis), (3) and the *ciliary muscles* (loss of accommodation and reaction to light). One or more of these branches may be contused or compressed by effused blood in fractures about the superior orbital fissure. Fixed dilatation of a single pupil occurs from the pressure of a blood-clot. Pressure upon the anterior division of the nerve may be caused by a tumor or aneurysm. In the posterior fossa the nerve may be compressed by cerebellopontile tumors, or one or more of the nuclei of the nerve may be involved by gummas or tumors growing near the floor of the third ventricle. Cortical lesions involving the face also frequently affect the third nerve.

The third nerve is involved in basilar meningitis, diphtheria, and tabes. The oculomotor nerves (third, fourth, and sixth) may have supranuclear lesions which affect movement rather than individual muscles, usually from hemorrhage.

Fourth or **trochlear** (*patheticus*) **nerve** originates in a nucleus in the floor of the cerebral aqueduct, and supplies the superior oblique muscle. When paralyzed, the patient has diplopia when looking down and mesad, and inclines the head with the chin toward the sound side.

Fifth or **trigeminal** (*trifacial*) **nerve** may be involved: (1) In the **pons** from hemorrhage, softening, tumors, bulbar paralysis, or disseminated sclerosis; (2) at the **base of the brain** from meningitis, tumors, fractures, or caries of the petrous bone; or (3) **distal to the semilunar (Gasserian) ganglion,** the *first division* being involved by tumors, thrombosis of the cavernous sinus, aneurysm of the internal carotid, cellulitis of the orbit, or the *second* and *third divisions* by growths in the sphenomaxillary fossa.

Supranuclear lesions are rare, result from involvement of the posterior portion of the internal capsule, and usually are without motor involvement.

In fractures of the apex of the petrous portion of the temporal bone, the greater and lesser superficial petrosal nerves may be injured, with paralysis of the soft palate and uvula, difficulty in swallowing, and painful sensations in the ear.

The *sensory portion* supplies one-half of the face and scalp, the anterior two-thirds of the tongue (via lingual, chorda tympani, and facial), posterior third of tongue (via glossopharyngeal nerve), the hard and soft palate, the upper lip, nose, conjunctiva, and cornea. Irritative lesions cause neuralgic tingling and pain, anesthesia which may be followed by painless ulceration of the cornea from dust and abrasion, purulent involvement of the anterior chamber and destruction of the eyeball.

The buccal, nasal, and lacrimal secretions are diminished, and the sense of smell reduced from the absence of secretion. Herpes zoster in the area of the ophthalmic branch may be associated with irritative lesions. The motor portion is involved in infranuclear lesions, with loss of power in the temporal and masseter muscles on the affected side, and inability to move the jaw toward the sound side. On depression, the jaw deviates to the affected side due to the external pterygoid muscle. Mastication is possible by the muscles of the sound side. Spasm of the muscles of mastication also may occur.

Trigeminal neuralgia (*tic douloureux, epileptiform neuralgia, neuralgia major, facial neuralgia*) is a paroxysmal neuralgic pain in the distribution of branches of the fifth nerve.

Etiology.—Women in middle or advanced life are more frequently afflicted than men. It is often associated with arteriosclerosis, and occurs in or distal to the semilunar ganglion. Sections of the involved nerve or ganglion appear normal or slightly fibrotic. The essential pathology is unknown.

Symptoms.—Paroxysmal attacks lasting from a few seconds to a minute or more, with violent lancinating, darting, shooting pain, like an electric shock or red-hot needle. It usually begins just under the skin, radiating along the course of the nerve from just lateral to the ala nasi, the infra-orbital foramen, or the mental foramen. The attacks, at first infrequent, tend to recur at shorter intervals. They at first involve the second and third branches, but may later spread to the ophthalmic branch which is rarely affected until late. There is associated local flushing, sweating, lacrimation, salivation, and twitching of the facial muscles. The skin tends to become thin and shiny, and the hair to fall out.

The paroxysms are excited by slight irritation of the skin or mucous membrane, as in eating, speaking, or from drafts of air or brushing the teeth. The condition tends to progress, with an increase of the area involved and in the frequency of the attacks.

Diagnosis.—*Dental infection, toothache:* Usually the teeth are blamed for the pain, and needlessly extracted.

In *functional neurosis* the patient is usually younger, the pain is not confined to the distribution of one branch or two branches of the fifth nerve, is less severe, and is not incited but may be relieved by the trivial causes that produce facial neuralgia.

Drug Addiction.—The presence of drug addiction usually excludes a true tic douloureux, as patients obtain insufficient relief from morphin and other hypnotics to continue their use.

Sinus disease should be suspected if the pain starts in the distribution of the supra-orbital nerve.

Neuralgia minor of the fifth nerve is characterized by pain radiating along

the nerve, with slight superficial tenderness limited to the distribution of the nerve. It occurs from caries of the teeth, errors of refraction, iritis, sinusitis, and the like. Reflex and referred pain may be due to local causes about the head, or be secondary to disease elsewhere in the body, as in general debility, anemia, neurasthenia, and similar diseases.

Prognosis is poor without operative intervention. Constant pain may induce a psychosis or suicide.

Treatment.—*Drugs:* Strychnin, in progressive ascending doses until muscular twitching is produced, is occasionally of some value. Salicylates, quinin, and iodids are of limited value. Sedatives: Gelsemium, aconite, aspirin, cinchophen, luminal, hyoscyamus all have a limited value. Morphin should not be used.

Operative Treatment: Nerve stretching, distal or *proximal neurectomy,* and *nerve avulsion* give such transient relief that they have been succeeded by the simpler and more efficient *injection of alcohol.* The injection may be peripheral,

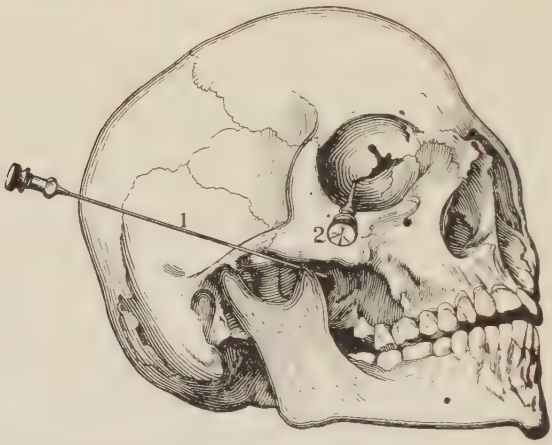


Fig. 553.—1, Injection of the second and third branches of the fifth nerve at the foramen ovale: 2, injection of the first branch of the fifth nerve at the foramen rotundum.

at the foramen of exit, or into the gasserian ganglion. This should give relief for from six months to two years, when the injection can be repeated (Schlösser's treatment). The injection of the gasserian ganglion may be followed by anesthesia and ulceration of the cornea.

Injection of the Fifth Nerve.—One to 2 c.c. of 80 to 95 per cent. alcohol are injected by a small hypodermic needle into the affected nerve-trunk under local anesthesia.

Peripheral Injection.—(a) For the third branch the injection is made in the mental foramen, through the cheek or mouth, or into the inferior dental nerve on the inner side of the ramus of the lower jaw, just above the spine of Spix. (b) The second branch is injected at the infra-orbital foramen. (c) The first branch is injected at the supra-orbital notch, taking care to avoid the pulley and tendon of the superior oblique muscle. If the superficial injections fail, the second and third branches may be blocked at the foramen rotundum at the base of the

skull. The needle is introduced directly below the zygoma, 1 cm. in front of the articular tubercle, directed inward and slightly upward, until the base of the skull is felt and then the resistance of the pterygoid plate of the sphenoid. The needle is carefully worked around the posterior border of the base of the pterygoid plate, and carried inward ½ cm. when, at a depth of 4 to 4.5 cm. from the skin, it should be directly over the foramen ovale. If carried too far posteriorly, the eustachian tube may be entered. For the foramen rotundum (first branch) the needle is entered at the lower lateral border of the orbit, and carried along the floor of the orbit into the inferior orbital fissure to the foramen, which is reached at a depth of about 5 cm. from the skin. The diffusion of the alcohol in the orbit may cause ocular palsy which usually disappears in about six weeks.

Injection of the semilunar (gasserian) ganglion is used to relieve trifacial neuralgia and to produce anesthesia for extensive operations upon the face.

Fig. 554.—Injection of the gasserian ganglion. The point of the needle is directed toward the temporal mandibular articulation in the plane of the pupil of the eye and should enter the foramen rotundum and gasserian ganglion at a depth of about 7 cm.

Technic.—Guided by a finger in the mouth a 10-cm. needle is introduced through the cheek opposite the second upper molar, the needle directed from the front toward the pupil of the corresponding eye and laterally toward the articular tubercle of the zygoma. The needle passes through the pterygoid muscle and at a depth of about 5 cm. strikes the smooth infratemporal plate, the plane in front of the foramen ovale. The hub of the needle is raised and the needle continued backward a short distance, when it enters the foramen ovale. If no paresthesia follows, the needle is continued farther back to the posterior wall of the foramen to obtain the response from puncturing the mandibular nerve. After entering the foramen the needle should not be introduced more than 1 cm. farther, and if cerebral spinal fluid escapes it indicates that the needle is beyond the ganglion and that no injection should be given. One c.c. of a 2 per cent. solution of procain is slowly injected, followed by 1 c.c. of an 85 per cent. solution of alcohol. Immediate anesthesia involving all three branches should follow.

Paralysis of the eye muscles, of the abducent nerve and masseter, and dropping of the jaw are transient. The patient should be kept supine for at least one hour after the injection. An herpetic eruption may appear about the mouth, cheeks, and eyelids a few days after the injection. To prevent *neuroparalytic keratitis* the eye should be protected by a Buller shield, which is worn for ten days, followed by close-fitting automobile goggles. Irrigations of 2 per cent. boric acid solution are made twice daily, with the installation of 10 per cent. argyrol if there is inflammation.

Resection of the Gasserian Ganglion.—Avulsion of the entire ganglion has been supplanted by resection or division of the posterior sensory root (Spiller-Frazier, 1901). The skull is exposed through a simple straight incision extending upward from the anterior border of the tragus. The fibers of the temporal muscles are separated and retracted and a rounded section of bone, 3 or 4 cm. in

diameter, extending to the base of the skull, resected, exposing the middle fossa. The dura is separated to the foramen spinosum, which is either plugged or the middle meningeal artery ligated and divided. The separation of the dura is continued to the foramen ovale, where the third division is found and traced to the posterior part of the ganglion. Here the dura is incised, exposing the sensory root, which is elevated by a small hook from the underlying motor root and divided. The division being proximal to the ganglion, there is no regeneration. The wound is closed without drainage. After the operation the eye should be frequently irrigated with boric solution and protected from dust and pressure by a suitable shield.

Auriculotemporal nerve (fifth nerve) is the secretory nerve of the parotid. Operative division of the nerve has proved useful in controlling inveterate parotid fistulæ. The auriculotemporal passes from the upper part of the mandibular nerve back under the external pterygoid, and may be reached after it passes between the sphenomandibular ligament and the neck of the mandible to enter the parotid gland. The secretory fibers come from the petrosal ganglion of the glossopharyngeal nerve. Operation upon the gasserian ganglion does not abolish parotid secretion. Destruction of the submaxillary ganglion, or division of the chorda tympani, produces a temporary arrest of the secretion of the submaxillary and sublingual salivary glands which may be followed by a continuous paralytic secretion in twenty-four hours. If secondary degeneration

Fig. 555.—Frazier's illuminating retractor for the brain. Useful in operations upon the gasserian ganglion.

of the gland does not occur, this continuous secretion may be so troublesome as to justify excision of the submaxillary gland. Disturbances in salivary secretion occur from disease or injury of the fibers of the chorda tympani, in their course in the facial nerve, the middle ear, or while incorporated with the lingual branches of the fifth nerve.

Sixth or **abducent nerve** originates in a nucleus in the upper part of the rhomboid fossa (floor of the fourth ventricle), and emerges between the pons and medulla. It supplies the lateral rectus muscle, and has fibers connected with the nucleus of the third (*conjugate deviation of the eyes*) and the eighth (*equilibrium*) nerves. It has the longest course of any nerve in the skull, but is seldom injured in fractures of the base. It is frequently pressed upon by tumors, gummas, or aneurysms at the base of the skull, especially tumors of the cerebellopontile angle, a medial strabismus resulting. There is convergent strabismus and diplopia on looking toward the affected side. The patient carries the head toward the affected side.

When the **nucleus of the sixth nerve is involved,** conjugate deviation occurs, both eyes looking away from the lesion. In **supranuclear lesion,** as in cerebral hemorrhage, the eyes look toward the lesion. If the lesions are irritative and produce spasm and not paralysis, the directions are reversed.

Lesions in the pons cause facial paralysis on the same side with conjugate deviation to the opposite side. From the proximity of the fibers of the third and fourth nerves to the nucleus of the sixth, a total ophthalmoplegia may occur, usually due to syphilitic disease of the rhomboid fossa.

Seventh or Facial Nerve.—From the rhomboid fossa and a nucleus in the pons the fibers wind around the nucleus of the sixth nerve and emerge at the lower border of the pons between the olive and inferior peduncle. The seventh and eighth nerves enter the internal acoustic meatus, the seventh entering the facial canal (aqueduct of Fallopius) and leaving the temporal bone at the stylomastoid foramen, passes through the parotid gland to supply the muscles of the face.

Fig. 556. The injection of the inferior dental nerve above the spine of Spix.

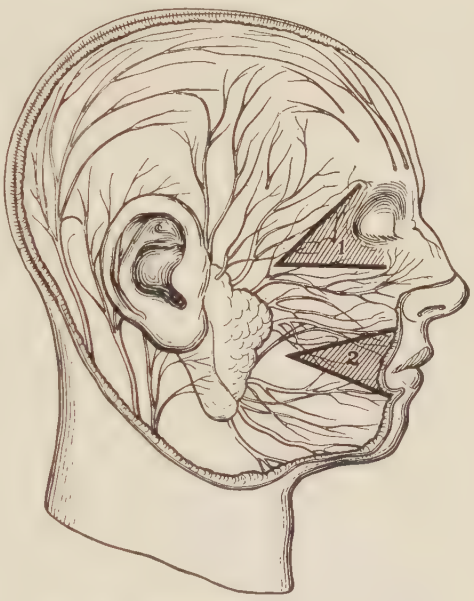


Fig. 557.—Distribution of the facial nerve: 1 and 2, Upper and lower triangular areas in which operations may be performed with little danger of facial paralysis.

Peripheral facial paralysis, or **Bell's palsy,** from interruption of impulses through the nerve is commonly the result of injury or operation about the mastoid, forceps delivery, or a cold. A so-called rheumatic form follows parenchymatous nephritis, probably from swelling and compression of the nerve within the facial canal. Syphilis and tetanus are occasional causes.

Diagnosis.—*Supranuclear lesion* (paralysis of the cerebral or upper neuron type) affects the side of the face opposite to the lesion, and occurs from tumor, abscess, hemorrhage, or softening in the cortex, corona radiata, internal capsule or, rarely, the upper portion of the pons. The upper neuron supplies the frontalis. The orbicularis oculi and the corrugator which are supplied by fibers from the third nucleus are unaffected, and consequently the purposeful voluntary movements are affected more than the emotional. Paralysis, therefore, involves the lower rather than the upper half of the face.

Hemiplegia is usually present. If conjugate deviation is associated, the patient looks toward the side of the lesion except in the early spasm.

Nuclear lesions usually occur as a part of a bulbar paralysis, with the involvement of other nuclei. They occur in diphtheria and in lesions of the pons. The upper fibers usually escape, the paralysis otherwise being of the lower neuron type.

Infranuclear lesions are of the lower neuron type and involve the entire peripheral nerve. There is crossed paralysis in the pons, with involvement of the face on the side of the lesion and the arm and leg on the opposite side. The nucleus of the sixth nerve is usually affected, the conjugate deviation being away from the lesion. The fifth nerve is also often involved. An associated involvement of the eighth nerve is common from cerebellopontile tumor, gumma, meningitis, a fracture, or from otitis media.

Within the temporal bone conduction may be interrupted from caries, otitis media, or operation. Taste is then lost in the anterior two-thirds of the tongue, unless, as is rare, the lesion is below the separation of the chorda tympani. If the stapedius is affected, there is hypersensitiveness to musical tones.

Facial diplegia is rare, but may occur from a double otitis media, lesions of the pons or base of the brain or, very rarely, from diphtheria. The paralysis is of the lower neuron type, and the skin is smooth. There may be pain referred to the region of the ear, and loss of sensation in a small area including the external auditory meatus. The eye cannot be closed (orbicularis oculi), the forehead cannot be wrinkled (frontalis), food collects in the cheeks from paralysis of the buccinator, and fluid runs out of the mouth while drinking. The speech is slightly affected from paralysis of the lips.

Prognosis varies with the cause; in otitis media it is usually bad; when due to cold, recovery is frequent and may be complete; when due to injury, the paralysis is usually permanent. If reaction of degeneration is not present within two weeks, recovery is usual in three or four weeks. When reaction of degeneration persists after three months, recovery is unusual.

Treatment.—*At the onset:* A blister and hot fomentations over the mastoid; purgation; sodium salicylate and potassium iodid should be used internally. *After two weeks:* Galvanism is used for fifteen minutes daily, with the positive pole behind the ear and the negative pole over the muscles. Massage of the facial muscles is then started.

If the nerve has been divided, the ends should, if possible, be united or, if the paralysis develops from otitis media, a complete mastoid operation should be performed, opening the aqueductus to relieve the nerve from pressure. For paralysis lasting six months or more, a nerve anastomosis or a face-lifting operation is used.

Anastomosis of the Facial Nerve.—If the nerve has been divided, an attempt should be immediately made to reunite the ends by suture. If injury, exposure to cold, or an infective neuritis has been followed by complete facial paralysis, and the reaction of degeneration is present after four to six months with no improvement, an anastomotic operation is indicated. Where a direct union of the injured nerve is not feasible, an accessory-facial anastomosis or, preferably, a hypoglossofacial anastomosis is performed. After the accessory facial anasto-

mosis it is difficult to dissociate movements of the shoulder from those of the face, thus the shoulder moves on attempts to produce contractions of the facial muscles.

Accessory Facial (Spinofacial) Anastomosis (Cushing).—Through an incision along the anterior border of the sternomastoid, about 5 cm. below the tip of the mastoid, the accessory nerve and its point of entrance into the deep anterior surface of the sternomastoid are exposed. A branch of the facial nerve is found by incising the posterior border of the parotid gland, until one of the larger branches to the nerve is reached. This is followed back to the main trunk. The facial nerve is divided distal to the lesion, and united to the proximal end of the accessory nerve at its point of entrance into the sternomastoid, over the posterior belly of the digastric.

Hypoglossofacial Anastomosis (Ballance and Stewart, Frazier-Spiller).—The hypoglossal nerve emerges at the hypoglossal (anterior condyloid) canal and lies on the inner side of the deep cervical vessels, passing forward between the internal carotid artery and the jugular vein to the lower border of the digastric muscle, where it curves forward around the origin of the occipital artery. It then runs forward above the hyoid bone, passes under the tendon of the digastric, the lower end of the stylohyoid and the mylohyoid muscles, and crosses the external carotid and lingual arteries.

Incision should be made from the anterior border of the mastoid process along the anterior border of the sternomastoid, to a point 1 cm. below the level of the hyoid bone, where it is curved forward for 2 or 3 cm. The facial nerve is located about $1\frac{1}{2}$ cm. mesial to the surface of the mastoid, at the junction of its lower and middle third, and is divided as close to the stylomastoid foramen as possible. The sheath of the sternomastoid is opened anteriorly and the muscle retracted backward, dividing the deep layer of its sheath at the level of the great horn of the hyoid. The hypoglossal nerve is located posteriorly where it crosses the external carotid, or anteriorly between the great horn of the hyoid and the posterior belly of the digastric. The nerve is divided well forward, so that it may be turned upward and forward and united without tension to the distal segment of the divided facial nerve.

Muscle Transplantation for Facial Paralysis.—Slips about 1 cm. wide, with the pedicle above, are taken from the anterior margin of the masseter through an incision along the nasolabial fold, and sutured to the tissues near the angle of the mouth (Lexer).

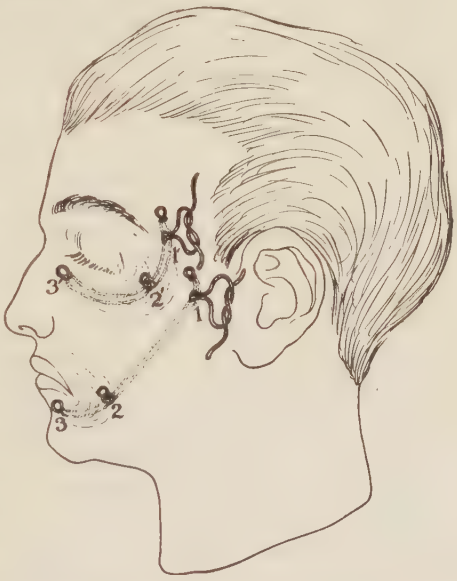


Fig. 558.—Lifting the face by the introduction of buried sutures of silk.

For paralysis of the eyelid, a slip from the anterior portion of the temporal muscle is obtained by a vertical incision posterior to the hair line, and united after forming the necessary subcutaneous tunnel, through a small incision close to the eye. The temporal muscle may also be used to support the mouth (Fenwick). Support may be obtained by the subcutaneous implantation of strips of fascia or silk thread, so as to raise the corner of the mouth and the lateral palpebral commissure (outer canthus) of the eye.

Tic convulsive (*histrionic spasm, spasm of the facial muscles, facial spasm*) is a spasm and not a true tic, and may occur from irritation of the cerebral cortex, compression of the nerve-trunk by tumor or the like, or as a so-called idiopathic facial spasm without evident organic disease.

Idiopathic facial spasm occurs more frequently in women than in men, between the ages of forty-five and sixty, without apparent cause, although, when established, paroxysms may be excited by cold, drafts, emotion, or voluntary movements. The spasms are unilateral, clonic, appearing in paroxysms and without paresis, involving chiefly the orbicularis oculi and zygomatic muscles. In severe attacks the spasms occasionally spread to the opposite side.

Partial facial spasms are extremely common as *blepharospasm* (spasm of the eyelid).

Treatment.—1. Schlösser's injection of alcohol into the nerve or the stylomastoid foramen, producing facial paralysis. The spasm may return as the paralysis passes, but relief is obtained for several months at least.

2. Injection of 5 per cent. phenol in the peripheral course of the facial fibers is a simple and often very efficient treatment. A fine hypodermic needle is introduced to the articular tubercle, withdrawn 0.5 cm., and 2 c.c. of the aqueous solution distributed in the adjacent tissues. The local paralysis which immediately follows disappears in ten days, and often the spasm does not recur.

3. Exposure and stretching of the facial nerve.

Eighth or **acoustic** (*auditory*) **nerve** consists of two separate parts: the *cochlear*, concerned with hearing; the *vestibular*, concerned with equilibrium.

The *cochlear nerve* has two nuclei in the floor of the fourth ventricle, and a representation in the cortex in the temporal gyrus; and, through the superior olive, communication with the third, fourth, and sixth nuclei concerned with the control of eye movements.

Lesions in the cortex cause word-deafness. The nerve may be affected at the base of the brain by tumors of the cerebellopontile angle, by fractures, hemorrhage, meningitis, and tabes, the latter affecting the nuclei.

Symptoms.—(1) *Hyperacusis*, sounds heard with unusual intensity, occurs rarely in hysteria and cerebral lesions and with paralysis of the stapedius from involvement of the seventh nerve. (2) *Dysacusis*, intolerance of sound, occurs with headache in neurasthenia and certain cerebral lesions. (3) *Tinnitus aurium*, ringing in the ear, may occur from wax in the external ear, anemia, neurasthenia, Ménière's disease, from quinin, salicylates or other drugs, middle-ear disease, aneurysm, and other causes. (4) *Deafness* may occur from cerebrospinal meningitis, tumors, fractures, hemorrhages, or edema. *Weber's tuning-fork test:* When the tuning-fork is placed on the forehead, it is heard louder on the deaf side if the conducting apparatus is affected, and on the sound side if the nerve is affected. *Rinne's test:* In nerve deafness the tuning-fork, placed over the external meatus, is heard when no longer audible on the mastoid. In nerve deafness hearing is better when there is quiet; in middle-ear disease it is better in noise.

Acoustic lesions produce vertigo, loss of co-ordination of the muscles of the head, neck and eyes, often associated with tinnitus and deafness from involvement of the cochlear nerve. Vertigo is especially marked in cerebellar lesions. The Bárány test is of great value in differentiating vestibular nerve lesions from those produced by cerebellar tumors. From fracture of the petrous portion of the temporal bone or other injury both nerves may be torn before they enter

the internal meatus. Effusion of blood or edema of the nerve may cause transient deafness, tinnitus, or vertigo.

Ninth or Glossopharyngeal Nerve.—This nerve supplies motion to the stylopharyngeus and middle constrictor of the pharynx, and sensation to the upper pharynx; also taste to the posterior third of the tongue. Lesions cause interference with speech, deglutition, loss of sense of taste in the posterior third of the tongue and, at times, ulcers on the tongue and edema of the glottis. The nerve is rarely injured, but occasionally is compressed by tumors lying near the medulla.

Neuralgia of the Glossopharyngeal.—While much less common than trifacial neuralgia, it is similar except as to distribution. *Neurotomy:* By a subtentorial craniotomy, the cerebellum is retracted, the cerebellopontile angle exposed, and with the eighth nerve as a guide, the smaller and more posterior ninth nerve identified and divided (Dandy, 1927).

Tenth or **Vagus** (*Pneumogastric*) **Nerve.**—This nerve may be involved at the base of the brain, in the neck, or in the thorax. (1) At the *base of the brain* it is, in rare instances, compressed by tumors, syphilitic or other forms of meningitis, or by aneurysm; (2) in *the neck* it may be injured from wounds, compressed by tumors; or damaged in the removal of malignant or tuberculous glands, in operations for goiter, and in ligation of the common carotid; (3) in *the chest* it may be impinged by a thoracic aneurysm, with involvement usually of the left recurrent branch. In rare instances the right nerve is compressed by pleural adhesions. The nerve rarely is affected in diphtheria, influenza, or from alcohol or arsenic poisoning.

The *vagus* sends branches to the heart, lungs, and abdominal viscera. It is the motor nerve of the stomach and esophagus.

Irritation of the cardiac branches slows the heart, paralysis accelerates it. Division of the nerve on one side causes little change in the pulse or respiration. Irritation or compression by a forceps may cause intermission of the heart and persistent vomiting. Ligation or division of the main trunk or its recurrent branch on one side produces unilateral abductor paralysis and interference with inspiration and phonation.

The vagus supplies motor fibers to the levator palati, and both motor and sensory fibers to the larynx. High division, therefore, is followed by paralysis of the soft palate and paralysis and anesthesia of the larynx.

Unilateral paralysis produces paralysis of the palate, partial anesthesia of the palate and pharynx, and paralysis of the pharyngeal muscles. The vocal cords are in the cadaveric position, the voice nasal and hoarse, and there is a harsh brassy cough.

If both nerves are divided, there is a resulting bilateral abductor paralysis with inspiratory stridor or crowing sound, or a dyspnea that may require tracheotomy. The voice is unaffected and cough is of normal tone.

Bilateral abductor paralysis involves the cricoarytænoideus posterior. The vagus has been successfully sutured after division.

Stimulation of the pneumogastric nerve during operation, by traction, pinching or torsion, may produce serious symptoms, including respiratory and cardiac arrest.

When exposed to operative irritation, the vagus should be blocked by applying procain or other local anesthetic. Division of one or both vagus nerves does not produce a dangerous effect on the heart. There may be only a slight and transient tachycardia from one nerve. Division of both nerves is dangerous, however, from the paralytic effect on the larynx. During inspiration the paralyzed cords fall together, producing asphyxia that may require immediate tracheotomy or intubation to prevent death. While the interruption or division of one recurrent nerve causes hoarseness, dysphonia and cough, with the division of both recurrent nerves there is danger of suffocation and need of an immediate tracheotomy.

The *recurrent nerve* is most often injured during the operation of thyroidectomy. During this operation it should be protected by retaining the posterior capsule of the thyroid, or leaving a thin layer of the gland at the sides of the trachea. When divided operative anastomosis may be attempted (as used by Frazier) or an anastomosis made with the descendens noni. Recurrent nerve paralysis is found in about 6 per cent. of the cases of toxic adenoma of the thyroid before operation. The superior laryngeal nerve arises from the vagus near the base of the skull and, through its internal branch, which pierces the thyrohyoid membrane and the posterior border of the thyrohyoid muscle, carries sensation from the mucosa of the larynx. Bilateral division produces anesthesia of the larynx, loss of reflex cough, and danger of inhalation pneumonia. Irritation of the external branch of the superior laryngeal causes spasm of the glottis. From its location the nerve may be affected: (1) In ligating the superior pole of the thyroid; (2) in laryngismus stridulus, from reflex irritation of the external laryngeal branch; (3) gastric disease; or (4) from tuberculous or malignant lymph-nodes in the neck or chest.

Treatment.—In laryngeal pain or spasm the superior laryngeal nerve may be injected before its division just above the great cornu of the hyoid bone. A long needle is introduced in the midline of the thyrohyoid space, carried along the hyothyroid membrane to the great cornu, and the injection made, using $1\frac{1}{2}$ c.c. of alcohol or 2 to 5 per cent. phenol. This has been especially useful in painful ulceration of the larynx.

Eleventh or **accessory nerve** is the motor nerve of the sternocleidomastoid and trapezius muscles, entering the anterior part of the sternomastoid on a line with the angle of the jaw. It emerges at the junction of the middle and upper third of the posterior border of the muscle, and obliquely crosses the posterior triangle of the neck to enter the trapezius. With some patients a shoulder-drop does not occur after division of the accessory nerve, as there is sufficient collateral innervation of the trapezius from the cervical plexus. Paralysis of the sternomastoid alone results in little disability, although it causes a flattening of the neck on the affected side.

The *cranial part* has nuclei in the medulla contiguous to the vagal nuclei. The fibers rejoin the vagus, and supply the muscles of the larynx and pharynx. The *spinal part* originates from the anterior horns of the first to the fifth cervical segments, the fibers passing up through the foramen magnum, leaving the skull through the jugular foramen, and supplying the sternocleidomastoid and trapezius muscles. On paralysis the shoulder of the affected

side may drop 2 to 5 cm., and the power of lifting the arm is impaired. The trapezius is also supplied by the third and fourth cervical nerves. Unilateral paralysis of the sternomastoid leads to restriction in rotation of the head to the opposite side. In bilateral paralysis, the head falls forward if the trapezius is affected; if the sternomastoids, the head falls backward. Fortunately both the sternomastoid and the trapezius have additional nerve-supply from the cervical plexus. The accessory nerve may be accidentally divided in the removal of malignant or tuberculous glands of the neck. When divided, an anastomosis should be attempted or, if this is not possible, the peripheral ends should be anastomosed to the anterior primary divisions of the third or fourth cervical nerves.

The nerve is rarely involved within the skull.

Acute and transient torticollis in children is often the first evidence of tuberculous cervical lymphadenitis, the diagnosis being confirmed by the appearance of palpable nodes a few days after the onset of the torticollis. Spasmodic torticollis may be treated by injection of the spinal accessory nerve as it enters the anterior border of the sternomastoid muscle.

Twelfth or **hypoglossal nerve** has a nucleus in the medulla in the floor of the rhomboid fossa, and is the motor nerve of the tongue. *Supranuclear* and *cortical lesions* are common in hemiplegia. *Nuclear lesions* occur in bulbar paralysis, tabes, syringomyelia and disseminated sclerosis, and are usually bilateral. *Infranuclear lesions* are usually unilateral, and result from syphilis, tumors, meningitis, fractures, cut-throat, operation for ligation of the lingual artery, removal of diseased lymphatic glands, and block dissection of the neck. In unilateral paralysis the tongue is protruded toward the affected side; there is atrophy or hemiatrophy of the tongue, the mucous membrane being thrown in folds, with interference with speech and mastication. Bilateral injury is followed by difficulty in swallowing, food and liquids tending to enter the larynx, necessitating a tracheotomy. Usually death from inspiration pneumonia follows.

Cervical sympathetic nerve, when damaged, produces Horner's syndrome with: (1) *Miosis;* (2) *reduction* in the size of the *pupil;* (3) *enophthalmos* or recession of the eye; (4) *narrowing* of the palpebral fissure, and (5) *loss of ciliospinal reflex* (the pupil does not dilate when the skin of the neck is pinched); (6) *anhidrosis*—the loss of sweating on the side of the face, neck, the upper part of the thorax, and the upper extremity of the affected side. Irritation of the sympathetic nerve of the neck produces dilatation of the pupil, widening of the palpebral orifice, exophthalmus, and unilateral sweating.

Phrenic nerve arises from the third, fourth, and fifth cervicals, and supplies the diaphragm. Irritation may cause cough or hiccup. Division from wound or operation, or paralysis from the pressure of tumor, is followed by ascent, immobility, and wasting and thinning of the affected half of the diaphragm. Unilateral phrenicotomy (division of one phrenic nerve) is used in tuberculosis of the lung, and other conditions when it is desired to produce a unilateral reduction in the capacity of the chest.

CHAPTER XXXV

THE SPINE AND CORD

Cerebrospinal fluid is excreted by the choroid plexus, not as in true secretion, but by dialysis and filtration from the blood in the capillaries through the Donnan-membrane equilibrium, the cerebrospinal fluid being in osmotic equilibrium with the blood-plasma.

Variations in pressure of the fluid result from changes in the capillary pressure in the choroid plexuses, or in the osmotic pressure of the plasma.

Circulation of Cerebrospinal Fluid.—From the choroid plexuses in the lateral ventricles the fluid passes through the interventricular foramina (foramina of Monro) and the medial aperture (foramen of Magendie) and lateral apertures (foramina of Luschka) in the roof of the rhomboid fossa to circulate slowly down the posterior surface and up the anterior surface of the medulla spinalis; re-entering the cranium to be absorbed by the veins of the pia, through the arachnoid villi, into the venous sinuses of the skull, and in small amount along the cranial and spinal nerve-trunks.

The total quantity of cerebrospinal fluid in the adult is about 150 to 180 c.c. It is rapidly re-formed, so that 200 c.c. may leak from the dura daily. With leakage or insufficient cerebrospinal fluid the brain rests on the floor of the skull, with *spinal headache* referred to the occiput and base of the skull when the patient sits, stands, walks, or is jarred. The pain is relieved by recumbency, and may be associated with pain and stiffness referred to the back of the neck.

Chemistry.—Cerebrospinal fluid normally is clear and colorless, and has a very constant specific gravity of about 1.0055, irrespective of age or disease. It does not coagulate on boiling. The protein content is 5 to 15 mg. per 100 c.c. in the ventricles, 30 to 40 mg. per 100 c.c. in the lumbar sac. Above 50 mg. per 100 c.c. is abnormal. Fibrinogen and thrombokinase are absent.

Cytology.—Blood is absent, and normally the fluid does not contain over 7 to 12 cells per c.mm., consisting of: (1) Small *mononuclear lymphocytes.* (2) Occasional *large mononuclear cells*, either hematogenous, or shed arachnoid cells.

Cerebrospinal pressure is determined by attaching a simple glass tube with a caliber of 2 mm. to the spinal needle which has been introduced, the patient's spine being horizontal. The height that the cerebrospinal fluid rises in the glass tube is recorded in millimeters. The range of pressure varies from 80 to 190 mm. With a mercurial manometer the pressure varies from 6 to 14 mg. of Hg, being 10/135 of that of cerebrospinal fluid.

The pressure is increased by each arterial pulsation (3 to 5 mm.), by expiration (5 to 10 mm.), coughing, crying, sneezing, and by compression of the internal jugular veins (*Queckenstedt's test*).

Spinal Localization.—The medulla spinalis occupies somewhat less than one-half of the spinal canal, being separated from the walls by the cerebrospinal fluid. The cord, shorter than the spinal canal, runs from the foramen magnum

to the level of the first lumbar spinous process in men, the second in women, the third in infants. The *cervical segment* of the medulla spinalis terminates at the level of the sixth cervical interspace, the *dorsal segment* at the ninth dorsal spine, the *lumbar* at the inferior border of the twelfth dorsal spine, and the *sacral segment* at the first lumbar spine. The *cervical enlargement*, including the lower four cervical and upper two thoracic segments, ends opposite to the seventh cervical spine. The *lumbar enlargement* lies opposite the last three thoracic spines.

The **spinal nerve-roots** pass down from their corresponding spinal segments, and emerge *above* the corresponding vertebra in the cervical region, *below* the corresponding vertebra in the dorsal and lumbar regions. In the cervical and lumbar regions the foramina are opposite the spinous process of the vertebra just above; in the dorsal region they are opposite the spinous process of the second vertebra above.

To estimate the *level of the segment* opposite a spinous process, in the cervical region, add *one* to the number of the vertebra. Thus the fifth cervical segment is opposite the fourth cervical spine. In the superior dorsal region add *two* to the number of the processes; from the sixth to the eleventh dorsal processes add the numeral *three*. The lower part of the eleventh thoracic spine and the interspace below it are opposite the lower three lumbar segments. The twelfth interspace and first lumbar spine are opposite the sacral segments (Chipault).

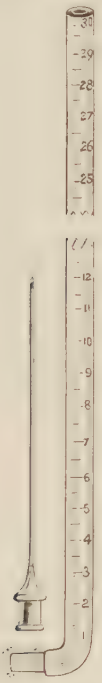


Fig. 559. Simple glass manometer for determining the intradural pressure in millimeters.

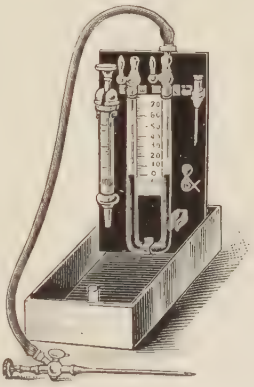


Fig. 560. Langdon's mercurial spinal manometer.

Spinous Processes.—The spinous process of the epistropheus (axis), and in certain patients the atlas, is palpable beneath the occiput. The spines from the third to the fifth cervical vertebræ, inclusive, are not clearly palpable, the sixth and the seventh (*vertebra prominens*) are very evident. In the dorsal region the most evident spines and interspaces are the eleventh and twelfth.

The third dorsal spine is on the level of the spines of the scapula, the seventh on a level with the angles of the scapula. The first lumbar interspace is opposite the angle formed by the erector spinæ muscle and the last rib. The

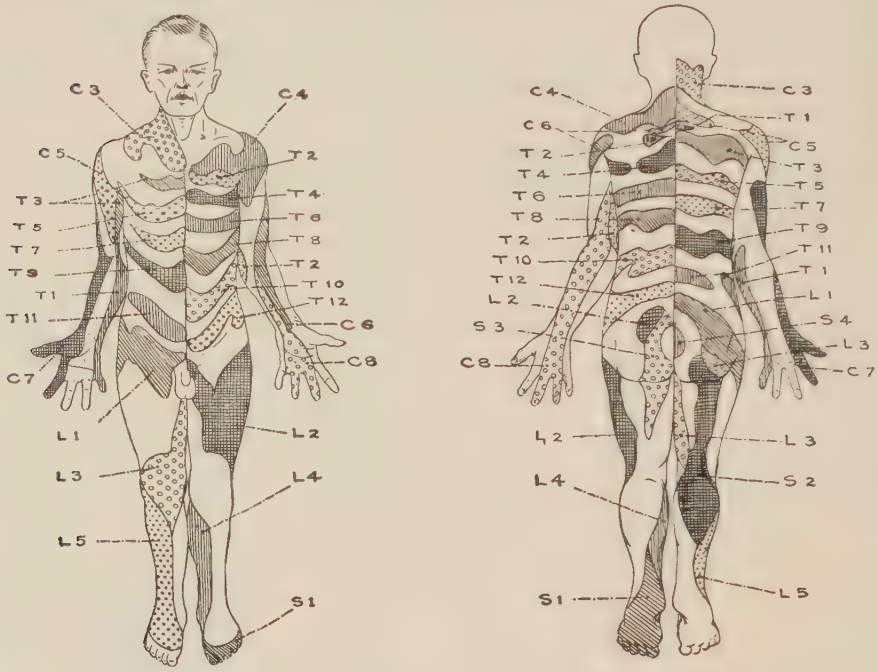


Fig. 561.—Sensory representation of the spinal segments upon the surface of the body.

line of the iliac crests crosses the fourth lumbar spine or interspace. By counting up or down from a known process the desired spine may be found.

The anterior surface of the bodies of the cervical vertebræ, from the first to the fifth, may be palpated through the mouth; of the coccyx and sacrum, through the rectum or vagina.

INTRADURAL LENGTHS (in millimeters) OF THE SPINAL NERVE-ROOTS (Soulie)

Cervical.		Thoracic.		Lumbar.		Sacral.		Coccygeal.	
No.	Mm.	No.	Mm.	No.	Mm.	No.	Mm.	No.	Mm.
1	3	1	29	1	91	1	185	1	266
2	8	2	35	2	110	2	196		
3	16	3	38	3	132	3	221		
4	18	4	43	4	151	4	239		
5	20	5	45	5	170	5	262		
6	23	6	47						
7	25	7	49						
8	27	8	49						
		9	52						
		10	55						
		11	58						
		12	81						

Circulation.—The anterior spinal artery supplies the gray matter, the two posterior spinal arteries the white matter of the cord. Being end arteries, any obstruction may be followed by degeneration of the nervous tissue in the area supplied by the penetrating branches, leaving the artery at the level involved. Below and above, the circulation is maintained by anastomotic vessels passing through the intervertebral foramina. In the spinal veins the flow of blood is from below upward, the lateral channels being few. Below a block, therefore, changes in the cerebrospinal fluid and even pressure symptoms may occur from the engorged veins.

Reflexes.—An increased reflex suggests interruption in the anterior cerebrospinal fasciculus (direct pyramidial tract) or the lateral cerebrospinal fasciculus (crossed pyramidal tract) above the level of the segment involved. An absence of reflex with retained proximal and distal reflexes is more valuable in localization, provided the paraplegia has not advanced to the flaccid stage.

Reflex of defence is a combination of flexion of the hip and knee and dorsiflexion of the toes, especially the great toe, when there is stimulation of the skin below the level of compression of the cord. The full bladder may be emptied; the anesthetic skin may show profuse sweating, and the previously flexed contralateral leg be extended.

Sympathetic reflex includes the pilomotor reflex or bristling of hairs on stimulating the skin either at nape of neck or in the anesthetic area. The sudomotor reflex, with hidrosis or anhidrosis, and the vasomotor reflex with vasodilatation are variable and of limited diagnostic value.

Localization of Reflexes.—The biceps reflex corresponds to fifth cervical, the supinator of forearm to sixth cervical, triceps jerk to seventh cervical, pronator reflex at wrist to eighth cervical, upper abdominal to upper sixth and seventh dorsal, middle abdominal to eighth and ninth dorsal, lower abdominal to tenth, eleventh and twelfth dorsal, cremaster reflex to the first lumbar, adductor jerk of the thigh to second lumbar, knee-jerk to third lumbar, Achilles or ankle-jerk to first sacral, plantar reflex to second sacral, bulbocavernous reflex to third sacral, and the anal reflex to the fourth sacral segment.

Vesical Symptoms.—The bladder receives impulses from the *sympathetic system*, through the hypogastric plexus. The sympathetic fibers leave the cord with the anterior roots of the third, fourth, and fifth lumbar nerves, and pass to the inferior mesenteric ganglion where the impulses are largely relayed by new neurons through the hypogastric plexus to the bladder wall.

Autonomic fibers arising from second and third sacral segments unite on each side to form the pelvic nerve which passes to hypogastric plexus, whence new neurons pass to the bladder wall. Ganglia upon these nerves in the bladder wall enable the bladder to contract without impulses from the cord. The compressor urethræ is composed of striated muscle, and innervated by the pudic nerve derived from the second, third, and fourth sacral segments.

Reflex Micturition (Barington): (1) *Distention of bladder* causes powerful sustained vesical contraction, which is abolished by dividing the medulla spinalis. The associated relaxation of the urethra is not abolished by dividing the thoracic cord. (2) *Running liquid through the urethra* produces a powerful and sustained contraction of bladder. The efferent path is the pelvic nerve,

the afferent is the pudic nerve. This reflex is also destroyed by section of the medulla spinalis. (3) *Distention of posterior urethra* leads to feeble transitory contractions of bladder. This reflex is not destroyed by division of the medulla spinalis in the lower thoracic region. (4) *Running liquid through the urethra* causes relaxation of the urethra, not destroyed by division of the cord in the lower thoracic region.

Lesions above the second lumbar segment cause urgency in micturition, and nocturnal, reflex, conscious, and finally unconscious urination. There is residual urine in the bladder, but no retention with overflow. The symptoms are similar with involvement of the second, third, fourth, and fifth lumbar segments.

From involvement of the second, third, and fourth sacral segments symptoms appear relatively early, including hypersensitivity, frequent desire, perhaps spasm, tenesmus, distention, and incontinence with overflow.

In involvement of the *cauda equina* the vesical symptoms are inconstant, usually late, with a flabby, distended bladder, and marked loss of expulsive power.

Sexual.—Lesions above level of second sacral segment diminish or abolish cortical control and conscious erotic sensation (pudic nerve).

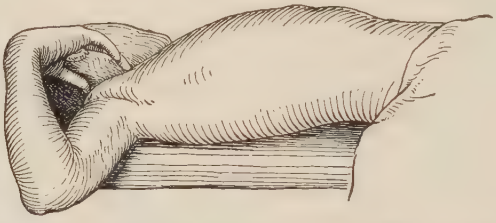


Fig. 562.—Position assumed by the patient in fracture of the fifth or sixth cervical vertebra with paraplegia.

Rectal Function.—The internal sphincter of plain muscle is supplied by the pelvic nerve, the external sphincter of striped muscle is supplied by the pudic nerve. Interruption above the second sacral segment gives persistent obstinate constipation with spasm of the external sphincter, to be followed later by relaxation and incontinence.

Cervical Region.—Complete transverse lesions above the fourth cervical segment are followed by asphyxia and death from paralysis of the diaphragm and intercostal muscles. The diaphragm through the phrenic nerve is supplied by the third, fourth, and fifth cervical segments. With involvement of the *fifth cervical segment* there is paralysis of the arms, legs and trunk, with preservation of sensation above the second intercostal space through the supraclavicular nerve derived from the fourth cervical segment. *Horner's syndrome* (*miosis, ptosis, exophthalmos, anhidrosis*) occurs from involvement of the cervical sympathetic. The sympathetic fibers descend in the cord, and leave by the lower cervical and upper dorsal roots. The respirations are diaphragmatic, there is hiccup, urinary retention, priapism, and at times glycosuria; bradycardia is usual, hyperpyrexia is ominous.

Sixth cervical segment lesion is associated with characteristic abduction and external rotation of the arms, with acute flexion of the elbows, the hands being

supinated and flexed from contraction of the muscles supplied by the upper segment. There is hemianesthesia of the arm, involving the ulnar side. Bronchitis and hypostatic pneumonia are frequent.

In **thoracic lesions** the level of anesthesia and paralysis is horizontal, and is not parallel with the intercostal nerves. A zone of hyperesthesia with girdle-pains may be found above the line of anesthesia. Meteorism occurs from paralysis of the abdominal muscles. Paralyses of the rectum and bladder are present.

Lesions of the upper dorsal region result in paralysis of the intercostal muscles which favors bronchitis and congestive pneumonia. Priapism is not infrequent. Death usually occurs from a pyelonephritis or an ascending myelitis.

Lower Dorsal and Upper Lumbar Region.—The lumbar enlargement gives origin to the lumbar and sacral plexuses, and contains centers for the bladder and rectum. Complete lesions here produce total paralysis and anesthesia of the legs and perineum, with incontinence of urine and feces.

Spinal segments representing the *lumbar*, *sacral*, and *coccygeal nerves* lie between the levels of the eleventh thoracic and the first lumbar vertebræ; injury of this region, therefore, is followed by paralysis of the lumbar and sacral plexuses, with anesthesia up to the level of the navel, priapism being absent.

Cauda equina is involved in injuries below the first lumbar vertebra, with paralysis of the muscles of the lower extremities except those supplied by the femoral, obturator, and superior gluteal nerves (the *psoas*, *iliacus*, *quadriceps*, *extensors*, and the *adductors*). There is paralysis of the perineal and penile muscles, and anesthesia of the perineal and genital region and of the foot and the lateral and posterior surfaces of the leg below the knee. The paralysis of the vesical and rectal sphincters causes urinary retention with overflow, and constipation.

The *prognosis* is more favorable than in lesions of the cord proper. Sensation may be present over the anterior and lateral aspects of the thigh, which are supplied by the lateral cutaneous and the cutaneous branches of the femoral nerve.

Conus medullaris may be injured as from a fall while in the sitting posture, with slight weakness of legs, anesthesia of a saddle-shaped area over the buttocks and back of the thighs, including the perineum, scrotum, penis, urethra, and anus; also paralysis of the levator ani and the rectal and vesical sphincters, with retained sensation of the testes.

Partial Lesions of the Cord.—Root symptoms, as formication, radiating pain, neuralgia, motor paralysis, twitchings and cramps, occur early from the pressure of tumors, but rarely from traumatic lesion. Partial lesions of the cord usually are shown by asymmetric motor weakness, greater on one side of the body, involving the feet and legs rather than the arms and hands, and the extensors more than the flexors. If the deep reflexes are absent early and then return in exaggerated form, the lesion probably is a partial one. Sensory disturbances, at times absent, are usually irritative in character. Temporary priapism may occur; retention of urine and feces is variable.

Prognosis.—Return of the deep reflexes with change from a flaccid to a spastic condition is favorable. Voluntary power returns first in the flexors, then the extensors, beginning with the flexion of the toes. An early differentiation be-

tween a total transverse lesion, concussion of the cord, and a partial lesion is often difficult.

Brown-Séquard syndrome of hemiparaplegia results from interruption of conduction of one lateral half of the medulla spinalis. *Below the level of interruption* there is spastic motor paralysis, with exaggerated reflexes on the side of the lesion and anesthesia to painful, thermal and, to a lesser degree, tactile impressions on the side opposite to the lesion. *About the level of interruption*, in the area of the spinal segment immediately above the lesion, there is a narrow bilateral band of hyperesthesia or, on the side of the lesion, at times complete anesthesia. The level of interruption is also shown by vasomotor reactions in the skin which may be intensified by the application of hot, wet towels (Fay, 1928).

Total transverse lesions occur from fracture-dislocation (*compression fracture*), stabs, or bullet wounds.

Symptoms.—Complete paraplegia with flaccidity and loss of sensation and motion below the level of the injury, with a narrow zone of hyperesthesia above the anesthetic area and, at times, radiating pain in the distribution of the irritated uppermost roots. The symptoms are symmetric. Asymmetry suggests an incomplete lesion. There is retention of urine, retention or incontinence of feces, priapism, dilatation of subcutaneous vessels, and elevation of temperature of the paralyzed parts; the deep tendon reflexes are permanently lost. The bladder shows distention and retention with overflow.

Secondary symptoms include hypostatic pneumonia and, if a catheter is used, cystitis. Bed-sores develop rapidly over the sacrum, heels, elbows, knees, ankles, and trochanters and, unless the greatest care is taken, may involve the bones and joints. Later, from the descending degeneration in the anterolateral columns, there may be violent contractures of the muscles of the leg with rigidity in flexion.

Prognosis.—Regeneration of the divided cord is impossible, the most that may be accomplished by operation is the removal of sources of pressure, irritation, and pain—as bullets, bits of bone, and other foreign bodies. A chordotomy or rhizotomy may be desirable to relieve pain or spasticity.

Treatment includes frequent changes in position (to avoid hypostatic pneumonia) and scrupulous care of the skin, with massage, bathing, and protection from maceration or prolonged pressure, to avoid bed-sores. The catheter should be avoided, urination being produced reflexly by stroking the thigh, or by gentle dilatation of the sphincter ani. If a severe cystitis develops, an indwelling catheter or, better, a suprapubic cystostomy may prolong the life of the patient. With care, a patient may live for a number of years after a complete transverse lesion, even as high as the lower cervical region. Without punctilious nursing, these patients usually die in from six weeks to three months from secondary septic complication of the urinary tract or lungs, or from bed-sores.

Diagnostic Tests.—1. **Increased cerebrospinal pressure** is found, especially in intraspinal or intracranial hemorrhage or tumor. The examination is made with the spine horizontal.

2. **Queckenstedt's Test.**—With a spinal manometer attached to the needle introduced in the cavity of the spinal arachnoid, an assistant compresses the deep jugular veins, when an immediate sharp rise occurs, followed by a fall in

pressure and return to normal. If there is obstruction to the circulation of cerebrospinal fluid between the needle and the skull, as from tumor (*spinal block*), the variations in pressure do not occur. Absence of response to jugular pressure suggests an absolute block. A sharp rise, maintained or slowly resuming the original level, suggests a partial block. Gradual delayed rise followed by sharp fall to the initial level is inconclusive.

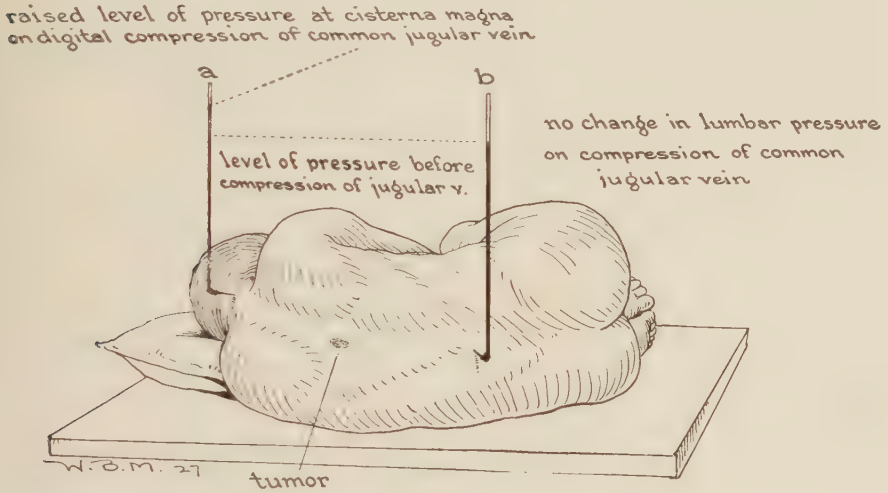

raised level of pressure at cisterna magna on digital compression of common jugular vein
a
b
level of pressure before compression of jugular v.
no change in lumbar pressure on compression of common jugular vein
W.O.M. 27
tumor

Fig. 563.—Method of determining a spinal block by Ayer's test with two manometers.

3. **Ayer's test** for spinal block depends on a combined lumbar and cisterna-magna puncture. Variation in the pressures recorded by the two needles indicates an intermediate block. Normally the pressures should be identical, except that the rise from cardiac systole is more evident in the upper manometer. *Variations* are noted from: (a) Jugular compression (Queckenstedt's test). (b) Respiratory movements. (c) Withdrawal of 5 c.c. of cerebrospinal fluid from the lumbar needle. This should cause a fall of 30 to 40 mm. in each manometer. A delayed or reduced response in one needle suggests a block. By moving the

Fig. 564.—Apparatus for leveling the spinal column.

needles to other interspaces the situation of the block may be more accurately determined. If both needles are shifted to the same side of the block, the manometric readings remain the same. If a tumor involves the cauda equina, the lumbar tap is frequently dry. A lumbar block may be demonstrated by inserting one needle in the twelfth dorsal and the other in the fourth lumbar interspace. A sacral block may be shown by an extradural injection of 50 to

70 c.c. of physiologic saline through the sacral hiatus, which should increase the pressure in the lumbar needle.

An increased pressure below the block may be due to the valvular action of a tumor, permitting a downward but not an upward flow, or the exudation of serum from distended veins below the growth. These evidences of spinal block are not absolutely pathognomonic, having a greater positive than a negative value.

Chemical changes in the fluid below the block result from obstruction to the circulation of the spinal fluid and compression of the cord, and also have a greater positive than a negative value. The changes include:

1. *Increase in Protein.*—(a) *Nonne's* or *Nonne-Apelt Test:* With 10 c.c. of cerebrospinal fluid in small test-tube 1 c.c. of saturated solution of ammonium sulphate is mixed, and after three minutes compared with a control tube containing cerebrospinal fluid alone. A positive reaction is shown by turbidity or precipitation in the first tube. Sulphosalicylic acid is also used as a precipitant. (b) *Pandy's Test:* To 1 c.c. of a saturated solution of carbolic acid in distilled water in a small test-tube 1 drop of cerebrospinal fluid is added. A positive test is shown by faint white clouds or, if the protein is in large amount, an actual precipitation. Increase in protein with no increase in cell-count (*Nonne's syndrome*) is strong evidence of presence of a spinal-cord tumor, especially if a block can also be demonstrated.

2. *Xanthochromia* (*Yellowish Cerebrospinal Fluid*).—Below a spinal obstruction the fluid may have a yellowish tinge from hematogenous pigment, derived by transudation from engorged veins, or the breaking down of tissue.

3. *Froin's Syndrome* (1903).—(a) *Increased protein content;* (b) *yellowish color;* (c) *spontaneous coagulation* with a (d) *normal or slightly increased cell-count.* This syndrome is characteristic of the isolation of a part of the subarachnoid space by a non-inflammatory process.

4. *Spontaneous coagulation* is due to large amounts of albumin, fibrinogen, and fibrin ferment. Coagulation is present in 24 per cent. of extramedullary tumors, in 90 per cent. of tumors of the cauda equina, and Froin's syndrome occurs in 20 to 30 per cent. The albumin may rise from normal of 0.02 to 2.01 gm. per 100 c.c. Increased protein content without xanthochromia or the complete Froin syndrome may be found in the fluid above the tumor.

The fluid in an isolated sac of the spinal subarachnoid is free from the ferments entering the cerebrospinal fluid from the choroid plexus or pituitary.

Wassermann, Kolmer, and *colloidal-benzoin tests* are only important in the diagnosis of syphilis.

Radiography.—Pneumography (Dandy): From 5 to 50 c.c. of air are injected within the spinal dura, an equivalent quantity of cerebrospinal fluid having been allowed to escape. Radiograms are taken after the patient has been in an erect position for one or two hours, with the hope that a bubble of air will be arrested by the tumor and be visible. Usually the bubble is indistinct and difficult to locate on the roentgenogram. After a few hours, pain (of some diagnostic value) may radiate around the body at the level of the tumor, from an air bubble passing the nerve-roots at the area of obstruction. Later, severe headache may occur from entrance of air into the ventricles.

Injection of Iodized Oil, Lipiodol (a colloid solution of 0.54 cgm. of iodin to 1 c.c. of oil).—The oil is heavier than cerebrospinal fluid, and after injection it may be arrested at the level of the tumor.

Technic (Sicard, Paras, Latlame).—The lipiodol usually is injected into the cisterna magna, or in the fourth, fifth, or sixth cervical interspace. *Cisterna-magna Puncture:* The patient is placed in a sitting or lateral position, with the head well flexed. The needle, fitted to a Luer syringe containing about 2 c.c. of normal saline solution, is entered at the center of a line joining the tips of mastoid processes. The needle is pushed steadily forward, close to the occipital bone, and penetrates the dura 3 to 5 cm. from the skin. The saline is slowly injected, as the needle is introduced in the soft tissues to prevent obstruction of the lumen. As the subarachnoid space is entered there is a sudden drop in resistance, and cerebrospinal fluid escapes.

CONGENITAL ANOMALIES

Spina Bifida.—A persistent complete or incomplete cleft of the neural arches, occurring once in 1000 births.

Varieties.—1. *Rachischisis*, a cleft of all structures from the central canal of the cord out, not associated with a cyst. This may be *complete*, involving the entire length of the spinal canal, or *incomplete*, involving a few vertebræ, usually in the lumbosacral region. There is (a) a median elongated area of reddish or brownish-red, soft, velvety, vascular granulation-like tissue (*area medullo-vasculosa*), representing the exposed cleft in the spinal marrow upon which the openings of the central canal may be visible. Surrounding this is (b) a thin membranous, pearly or pinkish, glistening zone of fused skin and pia (*zona epithelioserosa*), often with telangiectasis. (c) The surrounding skin (*zona der-*

Fig. 565.—Rachischisis, showing the cleft spinal cord (area medullo vasculosa), surrounded by the zona epithelioserosa and the zona dermatica. The openings of the central canal of the cord are shown.

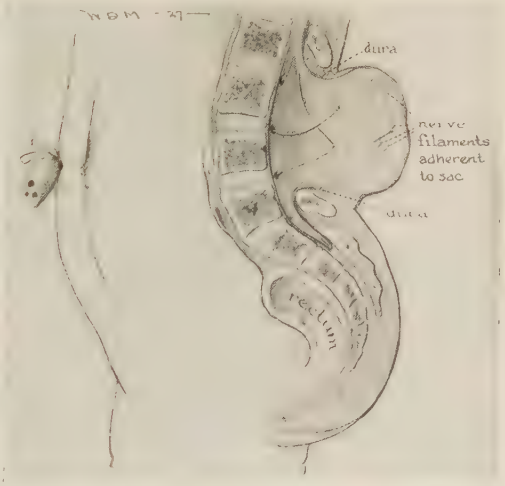


Fig. 566.—Lumbar myelocele showing the relation of the nerve-roots to the sac.

matica) may also show enlarged vessels and an excess of hair. From the open central canal, cerebrospinal fluid may ooze. The baby usually is stillborn or dies soon after birth.

2. *Myelocele* or *myelomeningocele*, the most common form, consists of the flattened cleft cord or cauda lying upon a subarachnoid cyst. If not ruptured, it forms a thin walled, oval or rounded, translucent, cyst-like tumor with a broad base and an apex of thin, reddish, granulation-like tissue (*area medullorasculosa*), surrounded by the *zona epithelioserosa* and the *zona dermatica* as in rachischisis. Cerebrospinal fluid may escape from the open central canal of the cord (*sweating spina bifida*). The sac is covered by the flattened exposed medulla spinalis, and consists of cord, nerve-roots, pia-arachnoid and, at the margins, epithelium and skin. The dura does not extend beyond the open bony groove. The nerve-roots pass through the accumulated fluid in the subarachnoid space and may be shown by transillumination. From their traction on the wall of the sac, especially near the median line, irregular grooves or umbilications are produced. At times the adjacent epithelium proliferates, and more or less completely covers the exposed thin layer of spinal marrow. As the cyst does not communicate with the

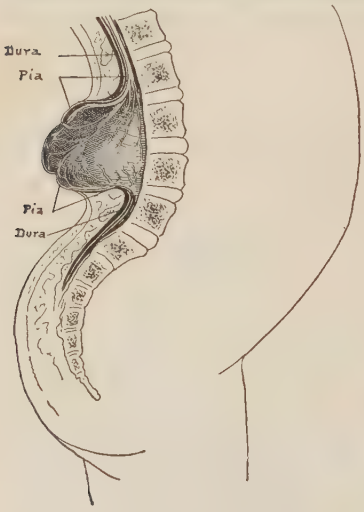


Fig. 567.—Myelocele or myelomeningocele (semidiagrammatic). Note thinness of sac wall, asymmetry from traction of nerve-roots, imperfect epithelial covering. The flattened cord or nerve-roots are exposed and lie upon the sac, which does not communicate with the central canal of the cord or the cavity of the arachnoid. Nerve-roots passing through the sac. Paralysis is present.

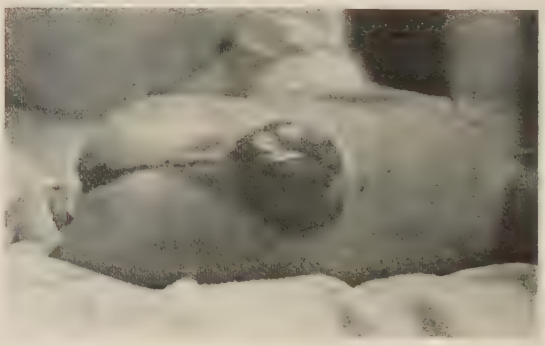


Fig. 568. -Lumbosacral myelocele, showing the central area of exposed cord or area medullovasculosa: the most common situation and variety of spina bifida.

general cavity of the arachnoid, it does not become tense as the infant strains or cries, nor does pressure upon it cause bulging of the fontanels. Defects of the lower extremities (especially talipes equinovarus, genu recurvatum, congenital dislocation of the hip) are often associated or, more rarely, exomphalos, extrophy of the bladder, hypospadia. Paralysis of the sphincters with incontinence of urine and feces is usual, and a more or less complete paralysis of the legs is common. Hydrocephalus may coexist or, more often, develops after birth.

3. *Myelocystocele* or *syringomyelocele* is a cyst formed by the dilated central canal of the cord, resulting in a large thin-walled sac with a broad base. The sac

Fig. 569.—Lumbosacral syringomyelocele. The thin but complete epithelial covering, translucency, communication with the ventricles, differentiate this type from myelocele and meningocele. On account of the low situation of the defect extensive paralysis is often absent, and results from operation, performed when the child is six to twelve weeks of age, are satisfactory.

Fig. 570.—Showing result four years after osteoplastic closure of large lumbosacral syringomyelocele, involving three laminæ. Operation when six weeks old, transverse closure, no secondary disability.

wall is formed of medulla spinalis and pia-arachnoid with an epithelial covering. The lining spinal marrow is so attenuated as to be recognized with difficulty. There is a brownish or grayish lining flecked with a whitish net-work, scrapings from which show the ciliated columnar epithelial cells of the central canal. No nerve-filaments traverse the cavity as in myelocele. The cyst is soft, symmetric, thin walled and, when compressed, there is increased intracranial tension. As in other forms, the dura does not extend beyond the bony groove. From pressure the overlying skin may ulcerate. Subcutaneous myxomas, lipomas, lymphadenomas, or teratomas at times lie adjacent to or over the sac. Paralysis, paraplegia, and developmental defects—especially those involving the bones and joints of the lower extremities—are frequently associated, and the paralysis may increase with the growth of the tumor from traction or pressure

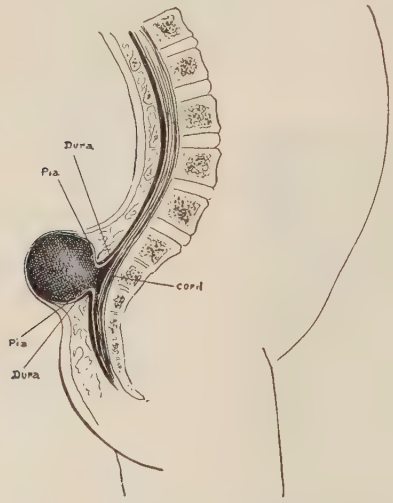


Fig. 571.—Meningocele. (Semidiagrammatic.) The contour is regular, the sac often pedunculated the overlying skin and subcutaneous tissue normal, the cord or nerve-roots do not enter the sac. There is no paralysis. The sac is formed of piarachnoid, the dura is not continued beyond the bony groove.

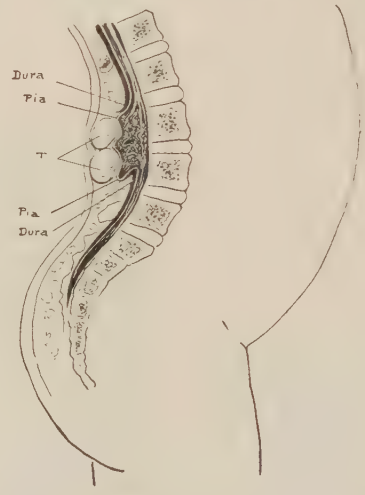


Fig. 572.—Spina bifida occulta. There is no outward protrusion, the bony defect may be occupied as in this diagram by a lipoma, and the cauda may be adherent to the walls of the small irregular sac. The overlying skin is normal or hairy. Early paralysis is rare.

upon nerve-roots. The lumbosacral region is chiefly involved. Spinal curvature is not unusual. The complete epithelial covering prevents early meningeal infection, and the condition is more hopeful for life than myelocele.

4. *Meningocele.*—The sac is formed by the pia-arachnoid without associated nerve-elements. It usually occurs below the level of the cord in the sacral region. As a rule, nerve-elements do not enter the cavity, the bony opening is small, the sac wall well covered by normal skin and subcutaneous tissue, and the mass distinctly pedunculated. Associated paralysis or other deformity is unusual. The contour of the sac is regular and not umbilicated. It forms less than 8 per cent. of spinæ bifidæ. The dura does not form a part of the sac wall. The prognosis is good.

5. *Spina bifida occulta,* a rare form in which no sac projects beyond the

vertebra. It may result from rupture and cicatricial contracture of a spina bifida before birth, or from the presence of a small meningocele. In the bony defect there is often a lipoma, myxoma, dermoid, teratoma, or other tumor. At times a tumor of the cauda equina is present. A band of adhesions may fasten and compress the nerve-filaments. The overlying skin is normal and flat, irregular and cicatricial, or elevated by the underlying tumor, and is usually thickly covered by dark hair which may grow to considerable length. Spina bifida occulta is found chiefly in the lumbar and sacral regions, rarely in the dorsal region, and no case has been recorded in the cervical region. Frequently no symptoms are present until about the age of puberty when, with the rapid growth of the body, there is traction and pressure upon the nerve-roots, causing trophic ulcers of the legs and sensory or motor disturbances involving the lower half of the body.

Fig. 573.—Anterior spina bifida and hydrocephalus in a newborn child. (Roentgenogram by Dr. G. C. Bird.)

6. *Anterior spina bifida* with a cleft through or between the vertebral bodies is rare, as is a meningocele protruding through the dura between adjacent laminæ.

Pathology.—The primitive neural groove, produced by the enfolding of the ectoderm, closes about the twelfth day of embryonic life, forming the central canal of the medulla spinalis. By the third week this has been reinforced by union of the epithelial layers over the primitive cord, and by the fifth week the mesoderm has insinuated itself between the epithelial layer and the cord, completing the primitive, osseous, and connective-tissue enclosure of the spinal marrow. These processes of closure are first completed in the dorsal region, then in the cervical, and finally in the lumbosacral region, explaining the fact that 85 per cent. of

spinæ bifidæ involve the lumbosacral region, 10 per cent. the cervical, and only 5 per cent., the dorsal region. If the developmental arrest occurs before the twelfth day, the cord, lamina, and overlying skin are cleft, producing rachischisis. In myelocele the defect occurs a little later in uterine life; in syringomyelocele about the third week of embryonic life, when the neural tube is closed and has been covered by epiblast but not by the mesoderm, and the distention of the central canal forms a large thin-walled sac. Meningocele indicates an arrest of development between the third and fifth weeks.

Etiology.—Spina bifida results from a defective environment of the germplasm producing arrest in development. In frogs it may be artificially produced by hatching the embryos in a 0.6 to 0.7 per cent. solution of sodium chlorid, but does not follow when certain other percentages are used. The sexes are about equally affected. Without convincing reason, the cleft has also been attributed to amniotic adhesions and pressure from an accumulation of fluid within the canal, as in prenatal hydrocephalus.

Fig. 574.—Dorsal myelocele: An uncommon site. The central area of exposed cord surrounded by the zona epithelioserosa is well shown.

Diagnosis.—In *myelocele* the sac is thin walled, shows a central ulcer-like area and, on transillumination, nerve-roots are seen running through the fluid. In *syringomyelocele* there is a complete epithelial covering, the sac is soft and compressible, and communicates with the ventricles, the contour is regular, and no nerve-roots pass through the cavity. *Meningoceles* have thicker walls from the covering of normal skin and subcutaneous tissue, tend to become pedunculated, and are not associated with paralysis. *Spina bifida occulta* is suggested by a patch of hair over the spinal column. The edge of the bony groove or an overlying tumor is found on palpation, and sensory or motor disturbances develop about the time of puberty. In all congenital neoplasms over the spine, the possible association of spina bifida should be considered.

Roentgenograms are valuable, especially in the diagnosis of anterior spina bifida.

Prognosis.—*Rachischisis* is almost invariably fatal, and operative treatment has rarely, if ever, been attempted. *Myelocele*, when untreated, is followed by death in the first year of life in 96 per cent. In 3 to 4 per cent., rupture, cicatrization, and partial spontaneous obliteration of the sac occurs. Operation

immediately after birth is followed by recovery, with more or less residual paralysis, in about 30 per cent. Secondary hydrocephalus is usual, unless

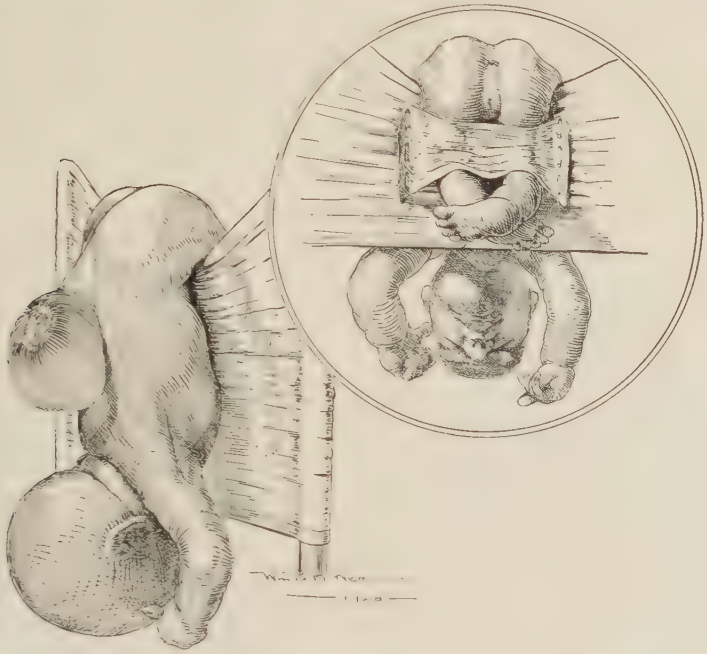


Fig. 575.—Head-dependent position used in operations for spina bifida.

operation is done before infection occurs through the exposed cord. If there is marked hydrocephalus, the prognosis is unfavorable. With *syringomyelocele*

Fig. 576.—Babcock's operation for spina bifida: Exposure of interior of sac.

about 80 per cent. of infants die during the first year of life. There is less danger of infection of the meninges, especially if the thin-walled sac be protected from

injury. Hydrocephalus is less frequent, and operation gives a more favorable prognosis. *Meningocele*, as a rule, does not endanger life and does not require early operation. *Spina bifida occulta* may, if operative treatment is neglected, cause serious paralytic symptoms from pressure or tension about the time of puberty. In *rachischisis* with evidence of viability, and in *myelocele*, operation should be performed within twelve hours after birth, as delay favors meningeal infection and hydrocephalus. Marked congenital hydrocephalus contraindicates operation, but operation may be attempted with the lesser degrees.

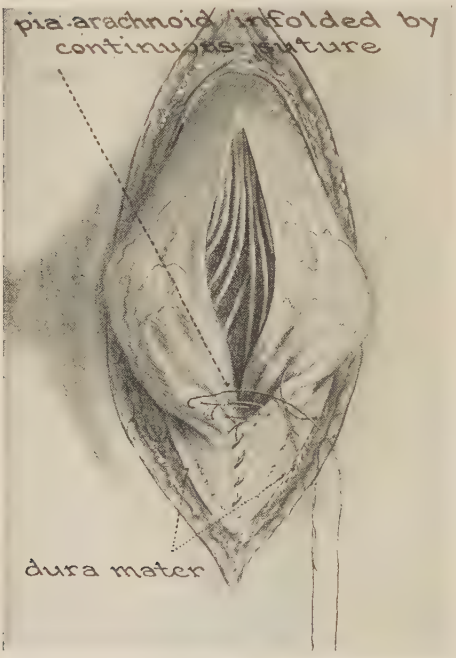


Fig. 577.—Babcock's operation for spina bifida: The epithelial covering of the sac has been excised, the nerve-roots and cord returned to the spinal groove. The pia-arachnoid is enfolded and closed by a continuous suture of fine catgut or silk.

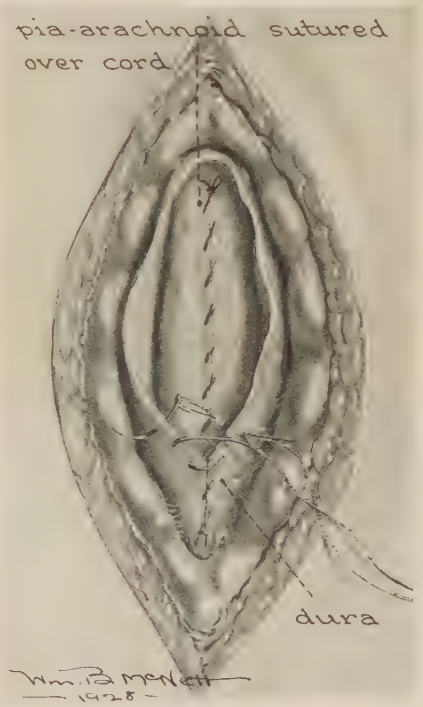


Fig. 578.—Babcock's operation for spina bifida: The dura has been liberated from the edges of the osseous groove and is united over the closed pia-arachnoid by continuous suture.

Treatment.—*Time of Operation:* With syringomyelocele and a good epithelial covering, the sac should be carefully protected, and operation deferred until the child has regained its birth weight. In meningocele operation is best delayed until the child is three years of age. In spina bifida occulta, operation should be done between the ages of three and twelve, or whenever pressure symptoms appear. For the common meningomyelocele, unless the parents desire the malformed infant to die, operation should be done during the first twelve or twenty-four hours after birth. Infection and hydrocephalus follow delay. If care is taken to keep the child warm and prevent loss of blood, the newborn baby will rarely die under the operation.

Babcock's Operation.—1. *Position:* To prevent leakage of cerebrospinal fluid the child is suspended (with the head dependent) from the groins, on a blanket fastened to the two upright standards of an ordinary operating-table. The legs are tied with bandages to prevent the child slipping from position, a hot-water bottle is suspended in front of the blanket to maintain the heat of the body, and an assistant on the opposite side of the blanket controls the arms, and watches the face and pulse during the operation. Denuded areas are cauterized by 3.5 per cent. tincture of iodin or pure phenol followed by alcohol, and the back carefully asepticized with one-half strength tincture of iodin. The wound area should be protected from escaping feces.

Fig. 579.—Babcock's operation for spina bifida: The dura has been closed. The cleft and rudimentary spinous processes are being mobilized by a miniature Satterlee bone-cutting forceps.

2. *Anesthesia:* With complete paraplegia no anesthesia may be required. For a newborn infant, 1½ cgm. of stovain or 2½ cgm. of novocain in 1 c.c. of 10 per cent. alcohol, very gently injected into the sac with the baby in the head-dependent position, gives an efficient spinal anesthesia for the lumbar or sacral type. For thoracic or cervical spina bifida, spinal anesthesia should not be used, but local anesthesia (½ per cent. procain with 1 : 100,000 epinephrin) employed.

3. By *sharp dissection,* avoiding the nerve-roots, the redundant portion of the sac and the outer layer of the area *medullovasculosa* is removed, adhesions to the margins of the spinal groove separated, the sac permitted to collapse within the groove where it is enfolded, and the pia-arachnoid closed by a continuous 000 chromicized catgut or a fine silk suture in a curved arterial needle. Care should be taken not to include nerve-filaments in this suture. The edge of the dura, where it blends with the edges of the spinal groove, is liberated for the entire length of the defect, and

sutured in the midline. If the margins of the bony groove are sufficiently developed, a ribbon of lamina, left attached above and below, is separated on either side by small Satterlee forceps and united by suture in the midline. Two ribbons, formed of sacrospinalis muscle and overlying aponeurosis and left attached above and below, are split off and slid to the median line, where they are united over the lamina by interrupted or continuous sutures. Finally the skin and superficial

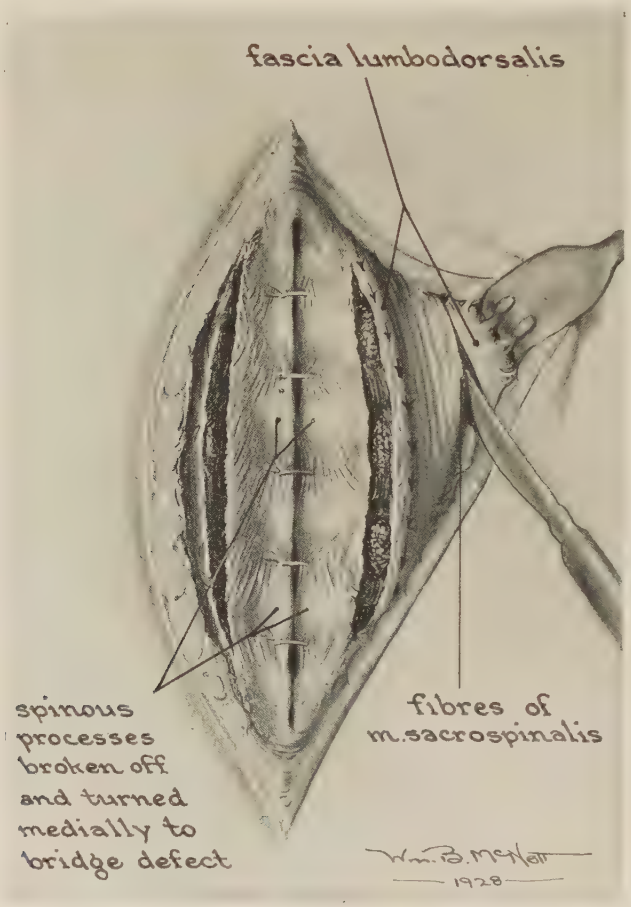

fascia lumbodorsalis
spinous processes broken off and turned medially to bridge defect
fibres of m.sacrospinalis
1928

Fig. 580.—Babcock's operation for spina bifida: The mobilized rudimentary spinous processes are united in the midline, closing the bony canal. The lateral muscles and fascia are mobilized.

fascia are freely mobilized, and united by interrupted sutures in a transverse or vertical direction, as is found most feasible. After the operation the child is placed in a semiprone position, with the buttocks higher than the head, and the wound protected from escaping urine and feces. Feeding by bottle or dropper is resumed immediately after the operation, and the child applied to the breast after forty-eight hours.

The wound is kept dry, painted with compound tincture of benzoin, and the final stitches removed in twelve to fourteen days.

Sacrococcygeal Growths.—Sacrococcygeal meningocele results from a bulge of the membranes through the cornu of the sacrum and coccyx with formation of a subcutaneous cystic tumor.

Sacral Hygroma.—A central cystic tumor over the sacrum which may be a meningocele which has been cut off *in utero* by the ingrowth of the vertebral arches.

Sacrolumbar hypertrichosis often occurs over a spina bifida occulta.

Dermoids and **teratomas** originate from the postanal duct, or may be bigeminal parasitic mixed tumors (*inclusio fœtus in fœtu*).

Congenital lipomas occur in the coccygeal region, tumors containing nerve-elements develop on the posterior surface of the coccyx from remnants of the

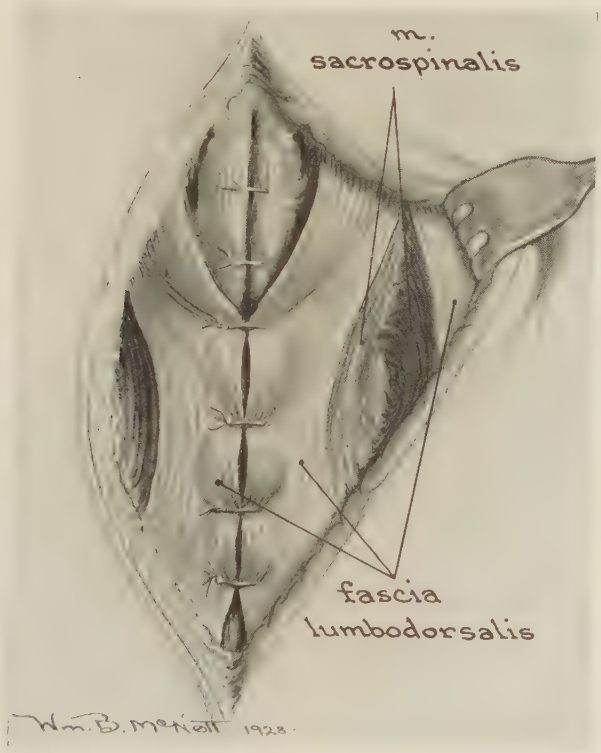


Fig. 581.—Babcock's operation for spina bifida: Mobilized ribbons of fascia and muscle are slid to the midline and united over the spinous processes.

embryonic cord; lymphangiomas and teratomas are also found over a meningocele on the dorsal surface of the coccyx. *Congenital* lipoma, teratoma, and cystic lymphangioma growing in front of the coccyx may extend high between the coccyx and rectum, but rarely are attached to the dura.

Congenital sacral tumors never extend beyond the posterior upper margin of the gluteal muscles, but enlarge toward the pelvis, between the legs, and displace the genitals and, especially, the anus downward and forward.

Treatment is excision. The enucleation of the anterior coccygeal and sacral tumors, despite their encapsulation, may be difficult on account of their high extension.

Caudal growths (Virchow) include: (1) *Complete tail*, with an actual increase in the number of coccygeal vertebræ. (2) *Imperfect tail*, not containing bone, connected with the vertebral column by rudimentary fibrous tissue. (3) *Tail-like* dermal appendices. These outgrowths are rare and easily excised.

Congenital Sacrococcygeal Sinuses and Fistulæ.—Postanal dimple, a depression over the tip of the coccyx, follows traction by the remains of neurenteric canal or the caudal ligament of Luschka. The depression, at times, communicates with the vertebral canal, forming a complete sacrococcygeal fistula, lined by cylindric or ciliated epithelium. The sinus or fistula should be treated by complete excision, and packing or suture.

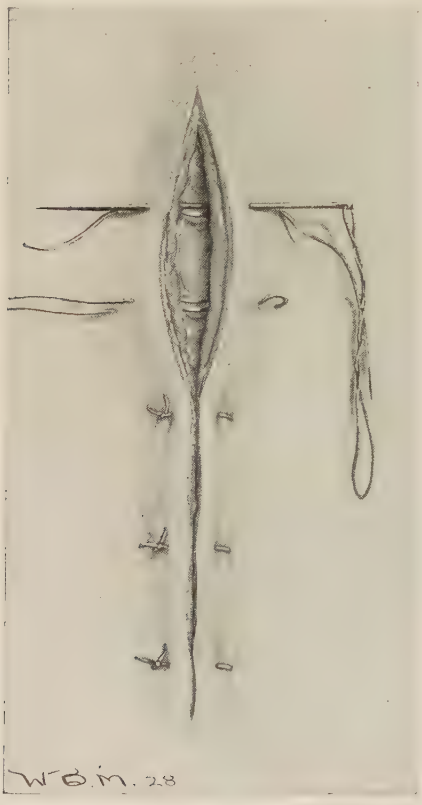


Fig. 582.—Babcock's operation for spina bifida: The skin and subcutaneous tissues are united in a vertical or transverse direction by vertical mattress-sutures of fine silkworm-gut or horsehair.

Pilonidal Sinus.—Not infrequently cystic masses, which contain hairs, form over the sacrum and coccyx in the midline. These tend to become inflamed, and form abscesses in early adult life, especially in men who show an excess of hair over the sacrum and coccyx. The abscesses rupture with the formation of one or more sinuses, from which hairs may be extruded. The condition is persistent, and recurs after operation unless the entire tract, with all hairs, is completely excised.

Fig. 583.—Postanal teratoma in an infant. Encapsulated.

Treatment.—The tract should be colored by injecting a solution of methylene blue or other dye, completely excised and, as a secondary troublesome hematoma usually follows primary closure, delayed closure or closure with drainage should be used. Care should be taken during the healing to shave the adjacent skin to prevent implantation of hairs.

TRAUMATIC INJURY

Concussion of the Medulla Spinalis.—An immediate arrest of function of the spinal cord from molecular injury, without visible or permanent lesion. There may, however, be edema or vascular engorgement, minute hemorrhages, or slight contusion of the cord.

Symptoms are motor paralysis, with limited sensory impairment. The condition is to be diagnosed from a total transverse lesion by the retention of sensation and the absence of priapism.

Prognosis is favorable. Within a few hours or days the reflexes return, followed by improvement in sensation and, finally, by return of motor power.

Treatment.—Rest. Diagnostic spinal puncture. Laxatives.

Traumatic spinal neurasthenia or **railway spine** (Erichsen) occurs in persons of neurotic type who have been in railway or other accidents, and who, as a rule, show no immediate evidence of serious injury.

Symptoms.—The patient may at first have been slightly dazed or mentally shocked, but the chief symptoms develop after some days, with nervousness, weakness, pain in the back, limbs, and head, especially in the lumbar region. There is mental change, loss of power of concentration, excitability, functional disturbances which may involve the bladder or uterus; vacillating areas of paresthesia, anesthesia, or hyperesthesia; insomnia, dreams, and loss of memory except for the details of the accident. The patient is irritable and emotional, often complains of vertigo, tinnitus, visual weakness and photophobia, pain on movement, hyperesthesia of the spine, loss of sexual power, irritability of the bladder, loss of weight, without change in the deep reflexes or muscles.

Prognosis.—The condition continues for weeks or months until any pending claims for damages are settled, whereupon the patient usually rapidly improves.

Treatment is that of neurasthenia, with avoidance of fixation of the spine by a cast or brace, or other measures that emphasize the patient's impression of disability. For functional spasticity of the lower part of the body, the dramatic relaxation produced by spinal anesthesia despite the patient's effort may be curative.

Sprains and **twists of the spine** chiefly involve the areas where there is the greatest range of movement, as the lower cervical and dorsolumbar regions, and may be associated with laceration of the interspinous ligaments and muscles. With laceration of the ligamentum flava, blood may enter the extradural space and produce compression of the cord. Nerve-roots may be stretched or lacerated with corresponding root symptoms. There is usually marked local tenderness, pain on passive or active movement, and rigidity of adjacent muscles without bony displacement.

Prognosis.—Chronic disability may follow a sprain of the spine if the early treatment is neglected.

Treatment.—Rest in bed with extension. Actinotherapy. Early massage, avoidance of active movement until all acute symptoms have disappeared. The possibility of a secondary tuberculosis is to be considered.

Dislocation of articular processes usually occurs in the cervical region, as the articular processes are here nearly horizontal; the fourth, fifth, and sixth cervical being most often affected. It results from falls upon the head or shoul-

ders, or forcible flexion or twisting of the neck, or even tonsillectomy. The upper vertebra is called the dislocated one. The dislocation may be: (1) *Complete* or *bilateral;* (2) *incomplete* or *unilateral;* and either *forward* or *backward.* In unilateral dislocation (the most common) there is pain and stiffness; the head is flexed, the face rotated toward the side opposite the injury, and the neck inclined toward the lesion with tension of the sternomastoid muscle. The transverse processes are out of line with those of the upper cervical vertebra, and there is pain on attempting to straighten the neck. The displacement may be felt by the finger in the pharynx. Roentgenograms should always be made. Root pressure pain may be associated. Usually there is no injury to the cord.

Treatment.— *Immediate reduction.* **1.** *Kocher's method:* Under general anesthesia gentle extension is made on the head, and the abnormal attitude exaggerated (dorsolateral flexion and rotation) to relax the ligaments and to restore mobility to the articular process. The head is then forcibly flexed toward the side opposite the injury, after which it is rotated back into its normal position. The after-treatment is that of a sprain.

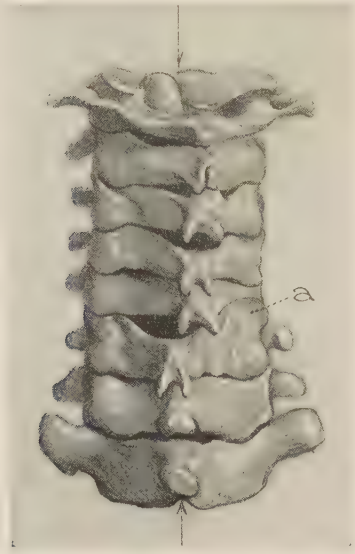


Fig. 584.—Unilateral dislocation of the fifth cervical vertebra.

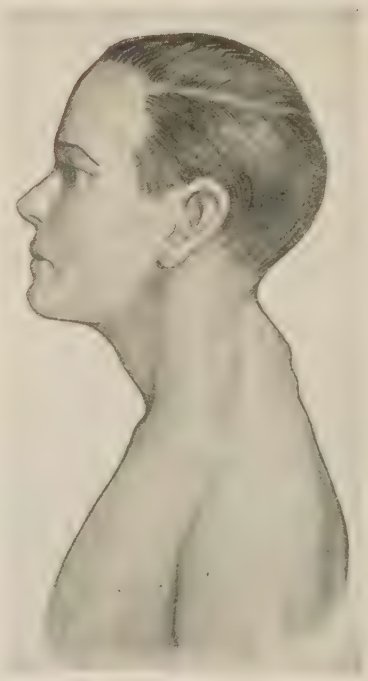


Fig. 585.—Deformity in dislocation of the fourth cervical vertebra.

2. Reduction may also occur *spontaneously,* under an anesthetic or during sleep. If reduction is unsuccessful, or more than six weeks have elapsed, head traction may be used with the patient recumbent for six weeks, after which a leather collar or other form of head support is worn.

Through a compensatory curvature of the lower spine most of the deformity of the dislocation usually disappears in time.

Dislocation of the spine in the dorsal and lumbar regions is always as-

sociated with fracture (fracture-dislocation). In the cervical region dislocation occurs chiefly between the fourth, fifth, and sixth vertebræ, and between the epistropheus (axis) and atlas.

Varieties.—The dislocation may be *complete* or *incomplete*, *forward* or (rarely) *backward*, and *unilateral* or *bilateral*. Bilateral dislocations are due to acute flexion; unilateral—to rotation and abduction.

1. *Occiput on atlas* is a rare and fatal dislocation.

2. *Atlas on epistropheus* follows a fall on the head or a sudden twist of the head or neck. The transverse ligament may rupture, or the dens (odontoid process) tear loose from the alaria (check) ligaments and slip from beneath the transverse ligament. The odontoid process may be fractured, especially in the fatal forms. Rotary dislocation of the atlas is the most common. The disability is often slight. If unilateral and anterior, the head is turned toward the opposite side,

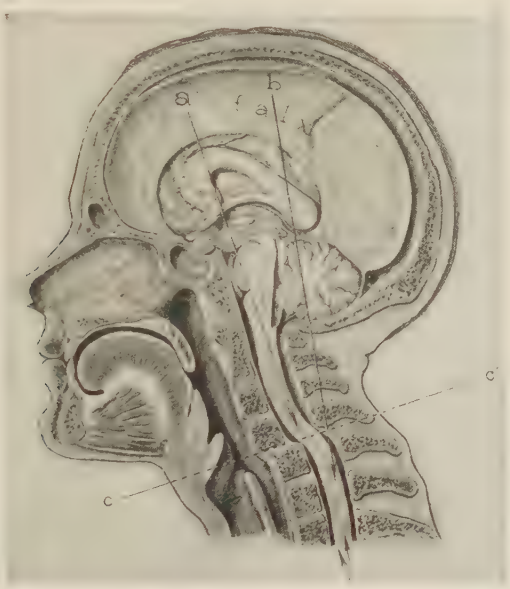


Fig. 586.—Change in the axis of the cervical spine from dislocation.

and rotation toward the affected side is restricted. If bilateral, the head is bent forward, and the chin may rest on the chest. Cord symptoms may be present with dyspnea and dysphagia.

Fracture of the atlas chiefly involves the anterior ring, and is not unusual. There is rigidity of the neck, asymmetric position of the head, the chin pointing away from the side of the lesion. Severe occipital neuralgia may be due to irritation of the greater occipital nerve. The spinous process of the epistropheus may be abnormally prominent, and irregularity of the bodies of the first two vertebræ felt through the mouth. Recovery occurs in about 50 per cent.

Treatment.—Gentle attempts at reduction, although dangerous, should be made after careful Roentgen study, especially if there is evidence of pressure on the cord. Traction, extension, and backward pressure are used, followed by the Minerva-type plaster-jacket and later a supporting collar. Artificial respiration

may be necessary for hours or even days if the cord has suffered pressure. Death may occur after several years from an injudicious movement or a secondary myelitis.

Cervical Vertebra.—*Unilateral forward dislocation* gives the attitude of torticollis.

Bilateral forward dislocation causes acute flexion of neck, with the chin upon the chest, and a prominent cervical spine.

Bilateral backward dislocation: The head and neck are extended upward and backward, with a concavity at the back of the neck, and fixation and shortening of the neck.

Treatment.—*Complete forward rotatory dislocation* and *complete unilateral dislocation:* (1) Anesthetic to relaxation. (2) Abduct head from side of injury,

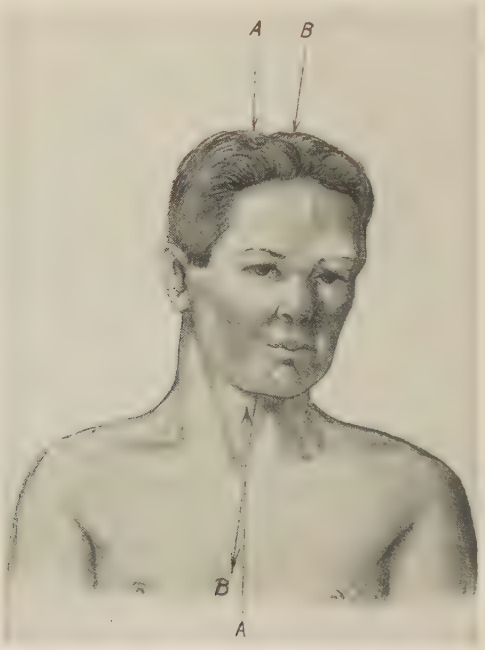


Fig. 587.—Unilateral dislocation of the fifth cervical vertebra showing alteration in the axis of the head and neck. The head is inclined toward the side of displacement. *A–A*, Normal axis; *B–B*, new axis.

with traction which is continued while (3) head is carefully rotated back into position.

Double rotary dislocation (one side being forward, the other backward) is reduced as described above.

In *bilateral forward dislocation* one side is reduced at a time.

Unilateral backward dislocation: Reduction is by traction, which is continued as the head is rotated forward and toward the injured side.

Treatment of closed or open spinal injuries, with evidence of pressure on the cord by bone or foreign body, should be by an early laminectomy and removal of foreign body or cause of pressure. Vertical chordotomy, done within

two hours after severe contusion of the cord, may prevent a permanent paraplegia (Allen).

Fracture of the spinous processes or **lamina,** as a rule, is produced by direct violence from a blow or missile, rarely by muscular action.

Symptoms.—Pain, tenderness, and limitation of rotatory or flexion movements without interference with weight-bearing. The spinous process may show abnormal mobility, tenderness, or even crepitus. There is associated muscular spasm. The symptoms may suggest a severe sprain of the back.

Diagnosis is confirmed by the roentgenogram.

Treatment.—Uncomplicated fracture of the spine limited to the spinous processes, after a preliminary period of recumbency may be treated with cast, strapping, and bandage; the patient being ambulant. If the laminæ are involved, rest in bed for six to eight weeks is required, a divided plaster-shell is used, the anterior portion being only buckled on while the patient is turned or

Fig. 588.—Fracture of articular process of the third lumbar vertebra. (Roentgenogram by Dr. G. C. Bird.)

Fig. 589.—Subluxation between the fourth and fifth lumbar vertebræ with scoliosis. (Roentgenogram by Dr. G. C. Bird.)

moved. After eight weeks the patient is permitted to be about in a plaster-jacket, after twelve weeks in a steel back-brace. The period of disability is about six months. A simple linear fracture of the lamina without displacement is less serious and may, like a fracture of a spinous process, require less arduous treatment.

Fracture of the transverse process is not infrequent, and results from muscular action or direct violence.

Symptoms.—Pain in the back, which may be referred to the knee or leg. Pain on movement, especially lateral bending toward the unaffected side. Muscular spasm, pain on hyperextension of the hip from the pull of the psoas muscle, tenderness on pressure. The displacement, as a rule, is slight.

Diagnosis is confirmed by a roentgenogram.

Treatment is similar to that for fracture of the spinous processes.

Fracture-dislocation (*broken back*) usually occurs when the body is hyperflexed while in a stooping position, especially at junctions of the more fixed to the more movable portions of the spine, as the lower cervical and lower thoracic regions. A fracture limited to the spinous or transverse processes is not infrequent. The usual fracture-dislocation consists of a complete bilateral dislocation of the articular facets forward, with a fracture of one or more of the bodies of the vertebræ running obliquely from above and behind downward and forward with displacement of the upper fragments downward and forward. The cord is frequently crushed.

Fig. 590.—Fracture-dislocation of the lumbar spine. (Roentgenogram by Dr. G. C. Bird.)

Fig. 591.—Fracture-disolocation of fourth lumbar vertebra. This vertebra is dislocated posteriorly. The right transverse process is fractured. There is a deposit of callus on both sides of the body of the vertebra, apparently ankylosing it with the third lumbar. (Roentgenogram by Dr. G. C. Bird.)

Symptoms.—Deformity, kyphos, pain on movement, evidence of severe injury to the spinal cord, shock.

Diagnosis is made by the symptoms, deformity, and roentgenogram. Of value is the evidence of subarachnoid bleeding shown by lumbar puncture, subarachnoid block shown by the combined lumbar and cisterna puncture of Ayer, and colorimetric, hydrodynamic, and chemical studies of the cerebrospinal fluid.

Crushing or **compression fracture of the vertebral bodies** involves one or more vertebræ with impaction of the spongy bone. It is the most frequent bony injury of the spine, and is due to forcible hyperflexion or compression of the spinal column, occurring at the junctions of the more fixed with more movable portions of the spine, as the lower cervical and lower thoracic regions.

Etiology.—Violent or, at times, apparently trivial injury from a fall on the feet, buttocks, or lumbar region. Falls on the head usually cause injury to the cervical spine. The anterior part of the vertebral body is more often compressed than the posterior. Paralysis is present in 30 per cent. (Wallace), occurring more frequently from injuries of the cervical region.

Symptoms.—(1) *Pain* and local tenderness, especially on pressing upon (a) the spinous process below the one forming the apex of the kyphos, or (b) the head or shoulders. (2) *Muscular spasm* of the adjacent spinal muscles. (3) *Deformity*—a limited sharp or rounded kyphos. (4) *Pressure symptoms*, neuralgia, pain, altered cutaneous sensibility, muscular weakness.

Fig. 592.—Crushing fracture of third lumbar vertebra. (Roentgenogram by Dr. G. C. Bird.)

Fig. 593.—Kümmell's disease not infrequently follows severe injury to the spine, a rarefying osteitis or compression fracture of the body of the vertebræ. It occurs in adults, with pain, difficulty in sitting, and posterior curvature. The treatment is fixation or support.

Differential Diagnosis.—In Pott's disease the intervertebral disk is involved early, in fracture it is intact.

Healing occurs with ankylosis. Large bony spurs may form that begin at the margins of the bodies of the vertebræ, extend up and down, and fuse, resembling hypertrophic arthritis.

Treatment.—Fixation and recumbency. Fixation is obtained by a plaster-shell composed of an anterior and posterior section. This supports the head and neck, back and legs, to a point below the knees. For fractures of the dorsal region, the head should also be supported; when in the lumbar region, continuous traction should be applied to both legs by weights and pulleys. The patient is placed on a Bradford frame, and the fixation is continued for

eight to ten weeks, when a Minerva-type plaster-jacket is applied for six to eight weeks longer. A back-brace may be substituted for the cast, or a Thomas collar for fractures of the cervical and upper dorsal regions. Recovery should occur within six months. If the deformity tends to increase, support should be continued. In rare cases the fusion operation of Hibbs or Forbes is desirable.

Traumatic Spondylitis (Kümmell's Disease, 1894).—A rarefying osteitis following injury of the spine, usually in adult or elderly men, with pain and weakness of the spine, neuralgic and motor disturbances of the legs, and increasing kyphosis. The softening and compression of the injured vertebræ may be favored by insufficient support and strain before the callus has solidified.

Diagnosis.—An injury to the back which improves under rest and support, but which weeks or years later shows a return of symptoms and angular kyphosis. The deformity tends to progress and may compress the cord, with resulting paralysis.

Treatment.—Fixation by plaster and Bradford frame for six to eight weeks, followed by a plaster-of-Paris jacket, succeeded by a brace. If the symptoms tend to recur when the patient becomes active, a fusion operation or the continuous wearing of a brace should be considered.

Spondylolisthesis, a forward and downward displacement of the lumbar spine into the pelvis in front of the sacrum, may be (1) *congenital*, with forward displacement of the body of the fifth lumbar vertebra upon the sacrum; (2) *from faulty development* of the spinal arch; (3) *from injury*, as forcible hyperflexion of the spine, a blow on the back, or great force pressing the shoulders down.

Symptoms.—Severe pain in the lumbosacral region. Sciatica, weakness or paralysis of the legs may be present. There is deformity, with shortening, and anterior and caudal displacement of the lumbar spine.

Diagnosis.—*Posture:* The knees are slightly flexed and pelvis tipped backward, the sacrum more vertical than normal. Usually, the upper part of the sacrum is prominent, with an abnormal hollow in the lumbar region above it. The trunk is abnormally short, the spinous process of the fifth lumbar cannot be palpated. The displaced vertebra may be palpable through the vagina or rectum. The lateral roentgenogram shows the body of the fifth lumbar displaced forward and downward, in front of the sacrum.

Treatment.—Early prolonged extension, followed by the use of a strong brace, or a fusion operation upon the spine.

Spinal Hemorrhage.—1. **Extramedullary hemorrhage** (*hematorachis*) occurs between the dura and cord, or the bone and dura. Paralysis develops, after a free interval, with severe root-pains and muscular spasm.

Symptoms.—Muscular cramps, spasmodic movements, shooting radiating pains in the distribution of the roots irritated, with hyperesthesia followed, if the pressure is sufficiently severe, by paralysis of gradual onset. It is most common in cervical regions, the arms being more affected than the legs. A paralysis of the lower neuron type, with flaccidity and atrophy of the muscles, occurs in the arms; paralysis of the upper neuron type, with spasticity and exaggerated reflexes, in the legs. *Gravitation paraplegia* (Thorburn) is due to the gravitation of blood to the lower part of the canal and its gradual spread upward, accompanied by an ascending paraplegia.

Diagnosis.—(1) History of progressive paraplegia after a free interval. (2) Spinal puncture showing blood in the cavity of the arachnoid. (3) Root symptoms.

Treatment.—Rest, support and fixation of the spine, ice locally, calcium chlorid intravenously, repeated spinal puncture.

2. **Intramedullary Hemorrhage** (*Hematomyelia*).—Hemorrhage into the cord usually occurs in the lower cervical region, from the forcible stretching of the cord by acute flexion of the neck. The blood enters the anterior cornu and central canal, with more or less laceration of the substance of the cord.

Symptoms.—(a) *From small hemorrhage:* Immediate paralysis or partial paraplegia from interruption of conducting paths, with the loss of pain and temperature sense, retention of tactile sensibility, and absence of painful root-symptoms. Retention of urine and feces, priapism, and miosis from involvement of fibers supplying the dilator of the pupil may be associated. If the cord is not seriously lacerated or does not undergo degeneration, improvement in sensation followed by restoration of motion may occur. (b) *From larger hemorrhages:* Disintegration of the cord occurs, with complete paralysis, atrophy, and anesthesia of the segments involved, and a spastic paraplegia of the parts below. Improvement with or without residual spasticity may occur in the segments below the lesion.

Treatment.—Rest, fixation, ice locally, serum and calcium chlorid intravenously, followed later by massage, electricity, and passive movements. Rarely a chordotomy may relieve by permitting the escape of blood from the cord.

DISEASES

Spinal curvatures include: (1) *Lordosis* or anterior curve, (2) *kyphosis* or posterior curve, and (3) *scoliosis* or lateral curve. A rotary displacement is often associated with a marked curvature.

The *curve* may be: (a) *Primary* or *predominant;* or (b) *secondary* and *compensatory*, due to a primary curve or to a tilting of the pelvis.

A compensatory **lordosis** occurs in pregnancy, with large abdominal tumors, in marked obesity, bilateral congenital dislocation of the hip, tuberculous disease of the hip, ankylosis, Charcot's disease of the hip, or it may be compensatory to kyphosis of another section of the spine.

Kyphosis in infancy results from debility; in adolescence from weak musculature, producing round shoulders; after middle life it is common in farmers, gardeners, and others who use a stooping posture while at work. In progressive muscular atrophy, poliomyelitis, osteitis deformans of Paget, and acromegaly, a cervicothoracic kyphosis is usual. A diffuse kyphosis or straight *poker back* occurs in the types of arthritis (spondylitis) deformans of Von Bechterew and Strümpell-Marie, with disappearance of the intervertebral disks and ankylosis of the vertebral bodies, the new bone connecting the vertebral bodies anteriorly. Partial or localized kyphosis results chiefly from Pott's disease. It also occurs from compression fracture of the spine, traumatic spondylitis, osteomalacia, and malignant disease. The localized projection is called a *gibbus* or *gibbosity.*

Treatment is nutritive, corrective, and supportive.

Scoliosis (*lateral curvature*) is the most common deviation of the spine.

A. *Static scoliosis* results from: (1) The *shortening of one leg* as in unilateral congenital dislocation of the hip, fractures of the thigh or leg with overriding, diseases of joints, flat-foot, knock-knee, or bow-leg. It is corrected by raising the heel and sole of the foot on the affected side. (2) *Shortening* of the muscles of one side in infantile hemiplegia, infantile paralysis, wry-neck; (3) *asymmetry* of the thorax or abdomen, as from empyema; (4) the *attitudes produced* by sciatica, sacro-iliac, or hip disease; (5) *positions assumed* to relieve pain, as in inflammation or disease of the vertebræ and in rickets; (6) *shape of vertebral bodies*, as wedge-shaped vertebræ.

B. *Postural scoliosis* often develops in young girls who are growing rapidly and are of poor physique, from faulty attitudes in study or work, ill-fitted desks and seats, fatigue, and the excessive use of one arm, as in carrying books or other weight. A primary curve, usually convex to the right, develops in the

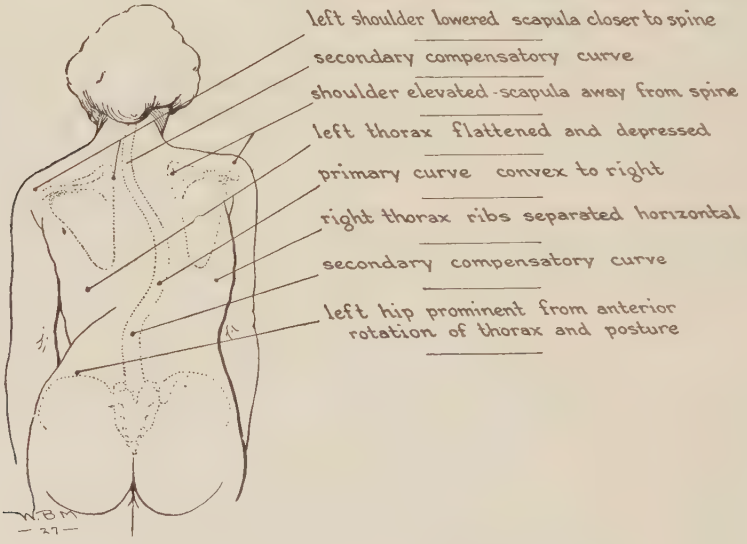

left shoulder lowered scapula closer to spine
secondary compensatory curve
shoulder elevated - scapula away from spine
left thorax flattened and depressed
primary curve convex to right
right thorax ribs separated horizontal
secondary compensatory curve
left hip prominent from anterior rotation of thorax and posture

Fig. 594.—Alterations of the thorax in scoliosis.

thoracic region with secondary compensatory curves above and below to the left, associated with rotation of the vertebræ around the vertical axis, so that the bodies face the convexity of the curve. In time, the individual vertebræ become distorted, the bodies wedge-shaped, the ribs become unduly prominent posteriorly on the side of the convexity, are flattened and crowded together on the side of the concavity. On the convexity the chest is long and narrow with diminished capacity, on the side of the concavity shorter and broader with increased capacity. Associated displacements of the viscera occur, and the pelvis may become obliquely contracted (*scoliotic pelvis*). There is no compression of the spinal cord.

Symptoms.—Scoliosis develops chiefly in girls about puberty as a primary thoracic curvature. In a typical case the convexity is to the right, the right scapula protrudes, with the inferior angle at the higher level and farther from the midline than the left. The right shoulder is higher, the right side of the neck

prominent, the left flattened. A deep sulcus develops in the left flank, below the costal margin and the brachiothoracic triangle. Usually there is general weakness and dyspnea on exertion.

Diagnosis is made by the inequality in the level of the angles of the scapulæ, the alteration in the positions of the ribs, and the spinal curves.

Treatment.—Muscular development and exercise, suspension, corrective posture. A support is to be used only in very advanced cases. *Abbott's operation* for advanced cases consists in: (1) Applying a supporting case, while the spinal curves are overcome as far as possible by extension. (2) Removing a section of case over the concavity. (3) Making constant and progressive pressure by thick pads over the side of the convexity to force the chest into the window on the side of the concavity.

The primary and secondary curves are often lost before the patient applies for treatment, due to loss of compensation. Correction by splints or plaster alone may be followed by a greater degree of relaxation than existed before the treatment, and so by an increase in deformity.

For the very severe cases with the loss of compensation, a fusion operation upon the spine (*Albee's or Hibbs' operation*) may be desirable.

Tuberculosis of the Spine or Pott's Disease (Percival Pott, 1779).—A tuberculous disease affecting the bodies of the vertebræ.

Pathology.—*Varieties:* 1. *Central* or *osteomyelitic form* occurs in childhood, begins in the interior of the bodies of the vertebræ, and is the most common. 2. *Periosteal*, the usual adult type, starts under the anterior longitudinal ligament.

1. In the osteomyelitic form the infection begins near the thin epiphysis, and the anterior part of the vertebral body is softened. The caseation and liquefaction spread to the adjacent intervertebral disks, and may involve contiguous vertebræ. The softened carious vertebral bodies, especially in the anterior portion, are compressed and crushed, producing kyphosis.

2. The periosteal form spreads under the ligaments from body to body, and may affect a number of vertebræ, producing no marked angle or gibbus, but a slight kyphotic bend. It frequently follows falls forward producing an indirect contusion of the vertebra. Pus accumulates under the periosteum and anterior longitudinal ligaments, and large abscesses may form which spread in the lumbar region (*lumbar abscess*) or along the iliopsoas muscle to the ilium and thigh, with the formation of a *psoas abscess*. Rarely the medulla spinalis is compressed by the pus or a sequestrum.

Recovery occurs by fibrosis, obliteration of the diseased area, and ankylosis of the adjacent joints.

Etiology.—The tubercle bacillus is carried to the vertebral bodies by the blood-stream. The central form occurs chiefly in children under ten years; the periosteal form in adults. In either form a fall or blow often localizes the infection.

Symptoms.—(1) *Pain* in the back at the site of the disease, which is dull and increased by jar or by pressure on the head. (2) *Referred neuralgic pains* from pressure on rami, as intercostal neuralgia, abdominal "girdle-pain," "stomach-ache." (3) *Muscular rigidity* and tension of the spinal muscles, shown by limited dorsiflexion and lateral flexion of the spine. (4) *Spinal weakness.* The patient may support the head by the hands, or the body upon the arms.

(5) *Deformity (kyphosis)—backward curve* develops from the periosteal type, a *backward angle* or *gibbosity* from the osteomyelitic form, with compensatory curves in a forward direction above and below the point of disease. In extreme cases (*hunch-back*) the sternum is bent forward, the ribs crowded together, the heart displaced, the head is hung low between the shoulders, and there is a lordosis of the lumbar region.

Abscess may spread: (1) From the *cervical region* to the retropharynx (*post-pharyngeal abscess*) and side of the neck, the axilla, or the mediastinum; (2) from the *dorsal region* behind the diaphragm into the psoas sheath, pointing (a) outside the erector spinæ, or (b) between the ribs along the intercostal vessels or, rarely, (c) upward into the neck; (3) from the *lumbar region* along the lumbar vessels, pointing outside the sacrospinalis in the lumbar (Petit's) triangle, forming an *iliac abscess;* or, by spreading along the iliopsoas to the thigh, a *psoas abscess.*

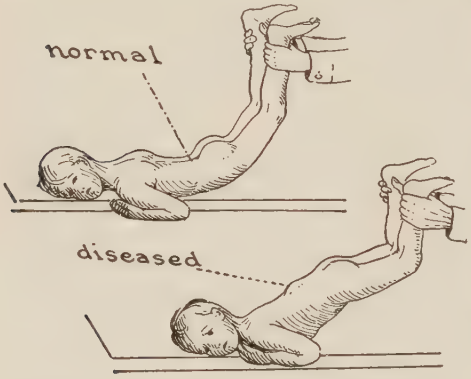


Fig. 595.—The rigidity of the spine in Pott's disease.

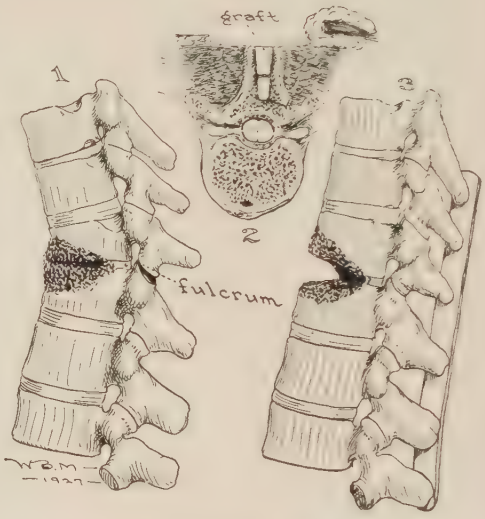


Fig. 596.—The mechanism of the Albee operation in preventing kyphosis.

Paraplegia may occur from pressure of tuberculous material or a sequestrum upon the dura and the cord or, rarely, from the narrowing of the bony canal. (1) *Acute paraplegia* is usually due to the formation of a subdural abscess. With immobilization and care, gradual regression with final recovery from the paralysis is usual. (2) *Sudden paraplegia:* A form occurs shortly after the onset of Pott's disease, due to edema and interference with the intrarachidian blood-supply. With immobilization the paralysis disappears within a short time. (3) *Incomplete paraplegia* of gradual onset, due to pachymeningitis, occurs usually in patients badly treated over a long period of time, and gives a poor prognosis.

Prognosis of Pott's disease is usually good, except when there is pressure upon the spinal cord, septic sinuses, bed-sores, cystitis, or extensive tuberculous disease in other organs. A rapidly fatal meningitis may follow perforation of the dura by an abscess. Sudden death occurs with disease of the atlas and epistropheus (axis) from dislocation and the compression of the cord.

Diagnosis is to be made from lumbago, sciatica, neuralgia, painful abdominal

diseases (as appendicitis, peritonitis, renal disease, gastric disease), sprains and other injuries to the spine, spondylitis deformans, spinal osteomyelitis, aneurysm of the aorta, malignant disease of the spine, hydatid disease of the spine, disease of the sacro-iliac or hip-joint. The abscesses should be differentiated from empyema, pyogenic abscesses, perinephritic abscess, appendicular abscess, abscesses of the pelvis.

Treatment.—This should include: (1) *Local rest* with support or extension for three years or more. (2) *General rest in bed* during the period of activity of the disease. (3) *Roborant* measures to increase the resistance of the tissues to tuberculosis, as ample intake of well selected food, abundance of fresh air, free exposure of the spine and body to the sun or to ultraviolet rays. (4) *Management of complications.*

Local and *general rest*, for a child, is best obtained by fastening the body to a Bradford frame upon which the patient may live from one to three years. By bending the metal sides of the frame, extension may be obtained. For older persons a double Thomas splint may be applied. For involvement of the cervical vertebræ, extension and support are obtained by the use of a jury-mast, or a padded collar or brace between the shoulders and head. When the disease becomes inactive, usually after a year, a jacket of gypsum or celluloid or a metal brace may be fitted. The support should be continued until the lesion has disappeared or a firm bony ankylosis is shown by Roentgen examination. Later, if there is increase in the deformity or other evidence of relapse, the patient should again be placed in a horizontal position in bed until the process is arrested.

Fig. 597.—Bradford frame.

Support by operation may shorten the period of disability to one year or less, the bone inlay graft of Albee, the spinal fusion operation of Hibbs or a modification being used.

Albee's Operation.—(1) Position, prone. (2) Incision is curved, beginning at a spinous process well above and ending at a spinous process well below the diseased vertebræ. (3) The supra- and infra-spinous ligaments are split vertically by a knife. The spinous processes are likewise split by a broad, thin osteotome to a depth of 2 or 3 cm., one side being fractured at the base to form a groove wide enough for the bone-graft. (4) The length and curve of the graft are accurately taken by bending a probe of lead, or other soft metal, to fit the groove, and the pattern obtained outlined by a knife on the exposed periosteum of the tibia. For greater strength the convexity of the curve should lie toward the crest of the tibia. (5) The graft, removed from the tibia by a power-driven saw and osteotome, is fitted in the spinal groove. Interrupted sutures of strong kangaroo tendon placed about 2 cm. apart unite the split supraspinous ligament over the graft. (6) The fascia and skin are united by interrupted sutures. The after-treatment consists in keeping the patient supine on a firm fracture-bed for five or six weeks. He is restrained by fastening a firm muslin sheet to the corners of the bed. A brace or plaster support is used only in exceptional cases.

Treatment of Complications.—Gibbus or hump, if recent, may be corrected. If old and characterized by bony or very firm fibrous fixation, forcible reduction of the deformity, suggested by Chipault, is dangerous and should not be attempted. For a recent, angular deformity Calot accurately applies a plaster-of-Paris jacket, leaving a diamond-shaped window through which the gibbus projects. By layers of cotton and felt pads and circular bandages, continuous pressure is made over the projection. The pads are renewed every three or four weeks and the pressure continued until the deformity is overcome.

Cold abscess may contain several liters of pus and burrow a long distance. The situation and movement of the abscess vary with the vertebræ affected. In any case continued drainage and mixed infection should, if possible, be avoided.

1. *Upper Cervical Vertebræ.*—A retropharyngeal abscess forms between the vertebræ and the prevertebral layer of the cervical fascia with inspiratory dyspnea and dysphagia. A fluctuating swelling may be felt, through the mouth on the posterior pharyngeal wall or, behind the sternocleidomastoideus.

The abscess may rupture into the pharynx with suffocation or point behind the sternomastoid or in the occipital region. The pus should be evacuated by aspiration or incision at the posterior border of the sternomastoid and the opening immediately sealed.

2. *Lower Cervical and Upper Thoracic Vertebræ.*—The abscess may point in the posterior triangle of the neck, in the axilla, enter the posterior mediastinum, extend behind the esophagus and trachea and rupture into the pleural cavity.

3. *Lower Thoracic Vertebræ.*—Usually the pus burrows along the intercostal vessels outside the pleura and points on the skin along the axillary line. Less often it passes through the crura of the diaphragm to enter the psoas sheath and form a *psoas abscess.* Rarely the abscess perforates into the pleura. The condition may be mistaken for necrosis of the ribs or a purulent pleurisy. A roentgenogram is helpful in the early diagnosis.

4. *Lumbar Vertebræ.*—A psoas abscess occupying the sheath of the psoas muscle usually forms, producing a mass in the iliac fossa, and later passing under the inguinal ligament external to the vessels to point on the skin at the fossa ovalis or the femoral triangle. While usually lateral to the vessels the impulse on coughing and the disappearance of the mass on recumbency may cause it to be mistaken for a femoral hernia. The presence of a mass in the iliac fossa and evidence of Pott's disease should always be sought. Again, the abscess may travel along the lateral border of the sacrospinalis with the lumbar vessels and nerves, to point through the lumbar triangle. Rarely, the pus escapes from the pelvis through the sacrosciatic foramen forming a subgluteal abscess or, through the obturator foramen to the mesial side of the thigh, or to the perineum.

5. *Lumbosacral vertebræ* are usually involved in adults with the production of a single or double iliac abscess. In *tuberculosis of the sacro-iliac joint*, most common in young men, the pus may form an iliac abscess, pass through the sacrosciatic foramen forming a subgluteal or perineal abscess, or across the pelvis to point near the opposite great trochanter. The iliac abscess may be mistaken for that from appendicitis.

The prophylactic treatment of a cold abscess is careful fixation of the diseased spine. An abscess may be largely absorbed after the Albee operation. For large abscesses one or more aspirations with possibly the injection of iodoform emulsion is advocated. For mixed infection, free drainage, sterilization, and excision of infected sinuses or an open treatment with actinotherapy should be tried.

Pressure upon the spinal cord and roots occurs in 7 per cent. of the patients with Pott's disease. In the upper cervical region with *atlo-axiod disease*, the atlas may dislocate forward and the dens (odontoid) press upon the medulla, causing sudden death. Lesser degrees of pressure from disease of the upper cervical spine may cause pain in the back of the neck and in the distribution of the cervical nerves, or complete or partial paraplegia. In the cervicothoracic region root-pains referred to the distribution of the cervical and brachial plexuses occur, or hemiparaplegia and involvement of the cervical sympathetic. From pressure in the lower thoracic and lumbar regions abdominal pain, lancinating pains in the buttocks and legs, increased reflexes, involvement of the sphincters and paraplegia may be produced. The symptoms are often attributed to indigestion, appendicitis, lumbago, or sciatica. To relieve the pressure, support, fixation and extension should be used and, rather rarely, laminectomy for progressive pachymeningitis or displacement of bone.

Spinal meningitis may originate in the spine, but more frequently occurs as an extension from the cerebral meninges.

1. **Pachymeningitis externa** follows extension of inflammation from bedsores, especially of the sacral region, tuberculous or syphilitic disease of the bodies of the vertebræ, and purulent abdominal or thoracic infection. The meningitis may occur either by (a) direct extension or (b) through the blood or lymphatic channels.

Symptoms.—(1) Pain in the back, increased by movement. (2) Segmental sharp lancinating pains from involvement of the posterior rami, increased by moving, coughing, or sneezing. (3) Areas of segmental paresthesia or anesthesia. (4) Involvement of the anterior rami, with chronic contractions or paresis.

Prognosis is grave, but varies with the cause.

Treatment.—Rest, fixation, treatment of the underlying condition, such as tuberculosis or syphilis, laminectomy for the drainage of abscesses.

2. **Pachymeningitis interna** usually occurs as an extension of an inflammation of the piarachnoid, the infection being by the Diplococcus intracellularis meningitidis, the pneumococcus, the B. influenzæ, Streptococcus, Staphylococcus, B. typhosus, the gonococcus, the B. tuberculosis, or the Spirochæta pallida. There is exudation, thickening and consolidation of the adjacent tissues, with meningomyelitis.

Symptoms include those from involvement of sensory and motor rami.

Treatment.—Exploratory laminectomy, removal of organized exudate.

3. **Leptomeningitis,** inflammation of the piarachnoid from infection by pyogenic bacteria, is most frequent in children, and often follows acute general infections, including the exanthematous diseases.

Symptoms.—Pain and stiffness of the back, rigidity, irritability. *Meningism*

(Dupré, 1894) refers to a mild form due to an attenuated organism or to a toxin. It is not associated with cellular changes in the cerebrospinal fluid, and is followed by recovery.

4. **Serous meningitis**, a distention of the cavity of the arachnoid with fluid, is due to excessive secretion or a blocking of the absorbent channels by exudate.

5. **Purulent meningitis** is characterized by great excess of leukocytes producing turbidity of the spinal fluid. This condition also occurs in plumbism. The *sensory symptoms* include irritation of the posterior rami, irritation of the sensory supply of the meninges, lightning pains, and paresthesia. The *motor symptoms* include evidences of motor root irritation or interruption, with spasm or paralysis. A general febrile reaction, with delirium and coma, occurs from cerebral complications.

Diagnosis is made by spinal puncture and the examination of the fluid. Clear or slightly turbid fluid may be withdrawn from the cisterna magna, and very purulent fluid from the lumbar region. Preponderance of lymphocytes suggests tuberculous or syphilitic infection; of polymorphonuclear leukocytes, a pyogenic infection.

Prognosis.—Spinal meningitis is always serious, and frequently fatal. The epidemic cerebrospinal form gives the best prognosis. The Staphylococcus albus, which may enter from spinal puncture or wound, produces a progressive infection with turbid fluid, followed by the formation of thick whitish pus. It progresses to a fatal issue in six to eight weeks. Secondary abscesses occur along the tracts made by spinal puncture. Occasionally recovery follows meningitis due to the hemolytic streptococcus or pneumococcus; frequently that from the meningococcus, and usually from that due to the gonococcus.

Treatment.—Reduction of cerebrospinal pressure, and removal of excessive fluid and exudate by repeated spinal punctures. The withdrawal of 40 to 60 c.c. of fluid is at times followed by rapid improvement. Irrigations and antiseptic injections into the cavity are harmful, but appropriate antitoxic sera injected within the arachnoid may be of value. A bacteriophage may be tried. Drainage by laminectomy, or occipital craniotomy with drainage of the cisterna magna, may be tried, but rarely gives relief. Drains should not be introduced within the dura. Rather rarely a desperately ill patient unexpectedly recovers.

TUMORS OF THE SPINE

Varieties: Lipoma, fibroma, endothelioma, glioma, psammoma, cholesteatoma, inflammatory and parasitic masses (including gumma, tuberculoma, and hydatid cysts) occur. *Secondary malignant tumors*, especially carcinoma and sarcoma, develop frequently in the bodies of the vertebræ, and produce secondary pressure upon the cord and spinal roots.

Primary tumors are usually *meningeal*, being intra- or extra-dural. *Intramedullary tumors*, developing within the cord, or *vertebral tumors*, arising in the bodies or less frequently the arches of the vertebræ, also occur. Most of the primary tumors are benign; 60 per cent. are extramedullary and intradural, occurring as small, rounded or elongated, encapsulated growths. The intramedullary tumors usually are gliomas and ineradicable.

Incidence of Spinal-cord Tumors (Schlesinger).—Sarcoma 27 per cent., tuberculoma 16 per cent., echinococcus cyst 12 per cent., neurofibroma 9 per cent., gumma 7 per cent., glioma 7 per cent., myxoma 3 per cent., psammoma and endothelioma 6 per cent.

Etiology.—Spinal tumors are slightly more common in males, usually between the ages of twenty and fifty, are less frequent and less often malignant than brain tumors, and occur in children as well as adults. A history of previous traumatism is not unusual. Tuberculoma is the most common of the intramedullary growths in patients under ten years of age.

Endothelioma (*perithelioma, arachnoid fibroblastoma, meningioma, psammomas,* or *leptomeningioma*) is the common non-malignant tumor of the spinal meninges.

Incidence.—One-half per cent. (0.43) of all autopsies, 2 per cent. (2.06) of all tumors, and 11 per cent. of spinal tumors are leptomeningiomas (Schlesinger). Leptomeningiomas comprise 55.7 per cent. of all intradural extramedullary tumors (Learmonth, Mayo Clinic).

Etiology.—Two-thirds of the tumors occur in females, chiefly between the ages of thirty and sixty. Peripheral neurofibromas may be associated. A history of preceding traumatism is rather exceptional.

Fig. 598.—Cholesteatoma measuring 14 x 2.5 cm. removed from within the cauda equina. The patient, a woman aged nineteen years, developed weakness of the legs and difficulty in urination after a fall on the buttocks, four years before with pain in the lower part of the back, dragging of the left leg, absence of patellar and Achilles' reflexes and impairment of tactile, pain, and temperature sense in the lower limbs. Voluntary rectal and vesical control promptly returned after the operation, with great improvement in the power of the legs. (Patient referred by Drs. W. E. Robertson and S. D. Ingham.)

Pathology.—The tumor is most common in the dorsal, less frequent in the lumbar, sacral and caudal, and least frequent in the cervical region. It may be: (1) *Posterior,* behind the posterior nerve-root. (2) *Posterolateral,* behind the dentate ligament and in front of the posterior nerve-roots. (3) *Anterolateral,* behind the anterior nerve-roots, in front of the dentate ligament. (4) *Anterior* or *ventral,* in front of the anterior nerve-roots. The posterolateral comprises about two-thirds; anterolateral, one-fifth; posterior, one-eighth of the cases (Learmonth).

The growth is encapsulated, firm or hard, gray or grayish-blue in color, of cylindric or spheric shape. Usually it is from 20 to 35 mm. long and 10 to 20 mm. broad. It has a dull grayish-white, avascular section, and may contain many gritty sand-like bodies (*psammoma*). Degeneration and cyst formation occur. Metastasis or recidivity does not occur. Cervical growths may extend through the foramen magnum, press on the medulla, and increase the intracranial

pressure. Leptomeningiomas are largely composed of elongated spindle-shaped cells with a small nucleus, occasional giant-cells, fibroglia and collagen fibrils. Glycogenic degeneration, hyaline degeneration, and calcareous degeneration (psammoma) are common.

Symptoms.—The meningeal tumors usually arise near the points of emergence of the spinal roots and give three distinct periods as to symptoms:

1. The *root cycle*, from pressure upon the posterior roots characterized by: (a) *Violent pain*, which may be mistaken for appendicitis, gall-stones, sciatica, neuralgia, rheumatism; followed by (b) *paresthesia.*

2. The *Brown-Séquard syndrome* of hemiparaplegia.

3. *Complete paraplegia*, with urinary and rectal incontinence. The usual sequence then is pain, followed by paresthesia and paralysis. The pain at first localized and unilateral, later radiates and becomes bilateral.

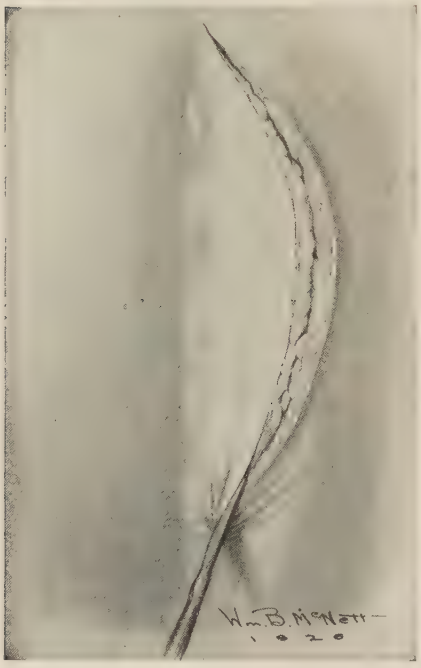


Fig. 599.—Laminectomy: A flap incision as illustrated or a median vertical incision may be used.

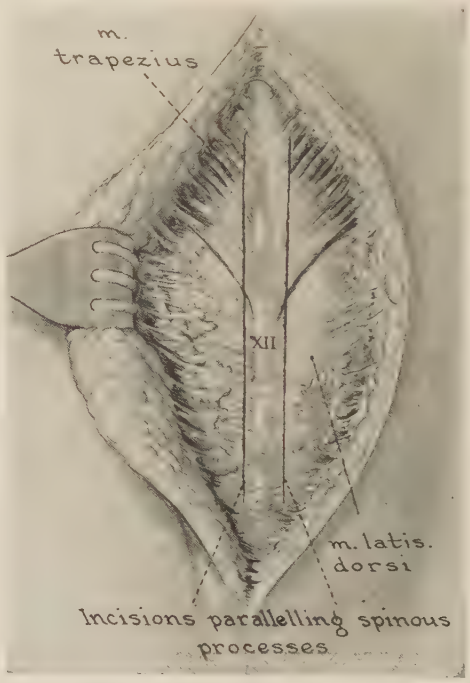


Fig. 600.—Laminectomy: The skin and fascia have been retracted and the spinous processes freed by lateral incisions.

Pain.—Root-pain is usually referred to the corresponding segment, rather than the course of the nerve-root. Tenderness may be present over the spine corresponding to the root pressed upon.

Sensation.—Little change in sensation occurs unless three roots are interrupted. The area of hyperesthesia above the tumor level represents the level of upper limit of the lesion of the cord. The upper level of the lesion may also be shown by cutaneous vasomotor reaction (Fay). Occasionally there is loss of visceral or splanchnic sensation. Lesions below the ninth and tenth dorsal segments are associated with distention of the stomach. Sensations in the

bladder and rectum should be distinguished from those due to the pressure of the distended organs. Tests may show dissociated anesthesia. The levels of pain (pin-prick), touch, and temperature sense should be determined, especially in the early cases before complete anesthesia is present. The tuning-fork is of value when applied to the abdominal wall, less accurate when applied to bone, although it may reveal differences in the perception of vibration.

Localizing Symptoms.—*Posterior tumors* first press on fasciculus gracilis (tract of Goll) and fasciculus cuneatus (Burdach), with incoördination, ataxic gait, astereognosis, lessened appreciation of difference in weight and of vibration.

Posterolateral tumors involve spinal-cerebellar tract, the posterior or direct, and the superficial anterolateral fasciculus or Gowers' tract carrying afferent subconscious impulses to the muscles and tendons, producing incoördination

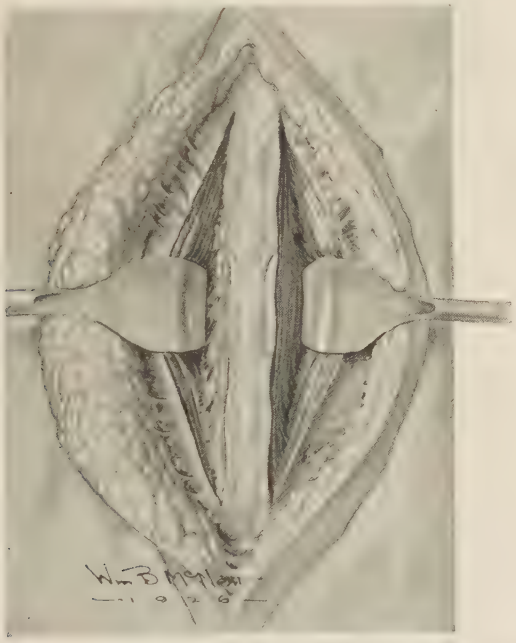


Fig. 601.—Laminectomy: Separation and retraction of the muscles from the spinous processes; hemorrhage is controlled by the pressure of gauze pads.

in areas of the same side that are innervated by segments below the level of the lesion.

Anterolateral tumors also affect the conductivity in Gowers' tract, and frequently the anterior and posterior nerve-roots.

Anterior tumors produce homolateral effects on the voluntary muscles, with irritation, muscular tremors, chronic spasm or complete interruption, and muscular atrophy, flaccid palsy, reaction of degeneration, and loss of reflexes. For complete muscular paralysis, the conductivity of all anterior nerve-roots from three adjacent cord-segments must be interrupted.

Brown-Séquard syndrome of hemiparaplegia occurs when the conductivity of one lateral half of the cord is interrupted.

A *reversed Brown-Séquard syndrome* results from displacement of the cord against the opposite bony wall.

Diagnosis.—*Tuberculoma* or *gumma*—cerebrospinal fluid shows pleocytosis, increased protein content, and in syphilis a positive Wassermann reaction. Evidence of tuberculosis or syphilis may be present elsewhere. Roentgenograms usually show associated lesions in neighboring vertebræ. Root-pain is usually severe in neurofibroma. Softer tumors, as myxoma and glioma, more frequently cause xanthochromia. Very vascular and firm tumors produce pressure-atrophy of the bone. Malignant tumors, of which sarcoma and glioma are most common, have a more rapid onset, the symptoms developing in one or two weeks. An associated hemorrhage may cause sudden changes in the symptoms with paraplegia or other evidence of pressure.

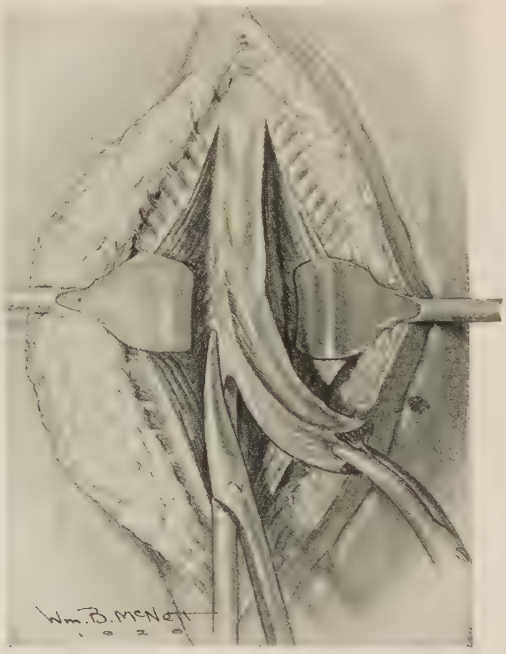


Fig. 602.—Laminectomy: Liberation of the spinous processes, which have been divided as near their laminæ as possible by a large Satterlee forceps. The attached soft tissues are being divided by scissors.

Extradural Tumors: Chondroma may be shown by the roentgenogram. Neurofibroma and lipoma springing from the extradural sac are without characteristic symptoms. Rigidity of spine over the growth is usual. Malignant tumors in the bony canal may show on the roentgenogram. A diffuse sarcoma of the dura may have a marked vertical extent, giving symptoms referable to many segments. Multiple myelomas are found in other bones; the characteristic blood-picture and Bence-Jones albumosuria are associated. With secondary malignant growths of the vertebræ, a primary focus should be evident, as a carcinoma of the breast, uterus, stomach, intestine, or prostate. The metastatic growths cause sudden paraplegia from the thrombosis of the vessels rather than by direct pressure.

Differential diagnosis of spinal tumors is to be made from extradural tumors, chronic myelitis, meningomyelitis, syringomyelitis, osteo-arthritis, and other conditions.

In chronic myelitis, the focus of infection is often in the prostate, there is no spinal block, the pain is not severe, or of the root type, and the lesion is of considerable vertical extent. In meningomyelitis a root-block may be present, as in myelitis, but a pleocytosis occurs. In syringomyelia the anesthesia is of the dissociated type, there is a characteristic early flaccid palsy of the small muscles of the hand, painless whitlow, and painless arthropathy without a spinal block.

Osteo-arthritis is very common in the lumbar spine, with root-pain from the bony outgrowths which may cause partial spinal block. Other arthritic lesions, the foci of infection, and roentgenograms confirm the diagnosis.

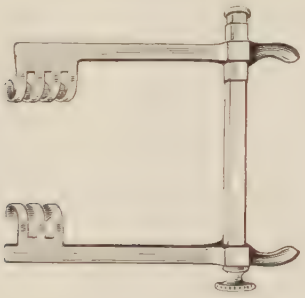


Fig. 603.—Frazier's self-retaining retractor for operations upon the spine.

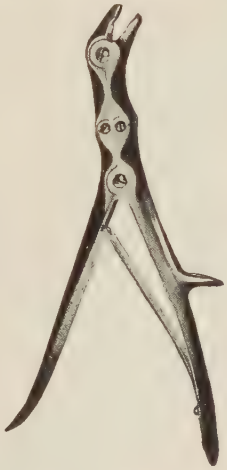


Fig. 604.—Small rongeur, double action; useful in removing laminæ.

Echinococcus cysts occur in the spinal canal. The serum shows complement fixation with echinococcus antigen, and a toxic neuritis of the cauda equina may be associated.

Pelvic tumors involving nerves of the lumbosacral plexus are found by rectal examination and the Roentgen ray. Hematomyelia and hematorachis have an acute onset, usually after trauma. In extensive cardiovascular disease, transverse lesions occur, suggesting a thrombosis of spinal vessels.

Treatment.—Tumors of the spine that are accessible should be exposed by laminectomy, and extirpated. Malignant tumors are to be treated by palliative measures, with fixation of the spine (if required), sedatives and narcotics and, at times, a chordotomy or rhizotomy to give relief from the pain.

OPERATIONS ON THE SPINE

Spinal Puncture.—See technic for spinal anesthesia (p. 568).

Cisternal Puncture.—The patient is placed on the side, with the head flexed on the chest, knees on the abdomen, the cervical and thoracic spine being level and not rotated. The occiput is prepared by shaving, scrubbing with ether, and painting with 3½ per cent. tincture of iodin. The needle is introduced in the midline, above the spine of the atlas close to the base of the skull, pushed carefully forward in the midline for 3½ cm., when the stylet is withdrawn. In an adult, at a depth of 4 to 5 cm., the fine snap is felt as the dura is punctured, and fluid runs from the needle. The

distance between the dura and the medulla at the lower border of the foramen magnum is $2\frac{1}{2}$ to 3 cm., and the needle should not be passed to a depth beyond 8 cm. The needle should follow the plane of the external auditory meatus and the glabella. The introduction of the needle at this point is very easy, and is nearly free from after-effects, as negative pressure prevents after-leakage, especially if the patient be kept in a semisitting position after the injection. Cisternal puncture is used for diagnosis and for intradural medication. Fluid injected here was found by Dandy to be freely distributed throughout the most distant branches of the subarachnoid spaces of the cerebral hemispheres in less than one hour.

Removal of Spinal Tumor or Foreign Bodies.—Location of the Tumor or Point of Pressure.— *Upper Neuron Type:* The level of the growth is roughly estimated by determining the extent of spastic paralysis present, finding the highest paralyzed muscle, and noting the segment of the cord that supplies it. The zone of cutaneous hyperesthesia or vasomotor reaction is valuable in indicating the upper level of pressure.

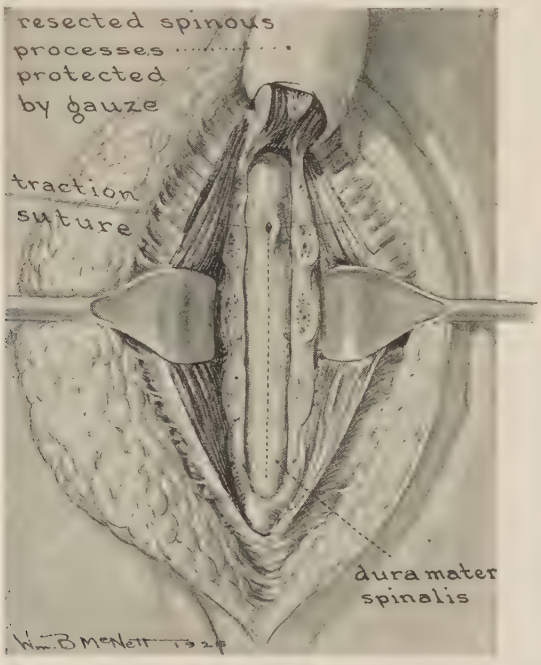


Fig. 605.—Laminectomy: Exposure of the dura. All hemorrhage having been arrested the dura is opened in the midline between traction sutures. The dotted line indicates the line of incision.

Lower Neuron Type: The situation of flaccid muscular paralysis is almost diagnostic of the site of pressure upon the cord, usually from pressure upon the anterior nerve-roots. Each muscle is supplied by three adjacent segments so, for complete paralysis, a growth of sufficient vertical extent must be present.

The tumor is often situated higher than the localizing signs would indicate. After exposing the cord, an injection of 5 c.c. of a sterile 1 per cent. solution of indigo carmin in saline solution may be made, through a lumbar or other interspace, to determine if a block is present.

Laminectomy is the method of operative approach to the spinal canal and its contents. The patient should be prone, with the spine raised in the area of operation to conserve the cerebrospinal fluid. Local anesthesia by infiltration and paravertebral injection is very effective. A ½ to 1 per cent. adrenalized procain is used. A vertical incision is made through the skin to the spinous processes, and the muscle carefully separated from the processes and laminæ. A sufficient number of spinous processes are now cut away by large Satterlee forceps, as far down on the laminæ as possible. The laminæ are removed by biting forceps, exposing the dura; all hemorrhage arrested by pressure of pads, forcipressure, ligatures, or other means, and the dura then cautiously incised in the midline. A tumor should be removed with any adherent dura. If a ventral tumor cannot be well exposed, slips of the dentate ligament may be divided close to the attachment to dura, grasped in mosquito forceps and the cord rotated by traction.

At the conclusion of the operation, the dura is carefully closed with a very fine curved needle and 000 chromic catgut or fine silk. The spinous processes are either replaced, and sutured as an osteoplastic flap to the lateral muscles, or removed. The skin and deep tissues are carefully closed. Disability from weakness of the spine rarely follows the operation. Great care is necessary in the dural closure to avoid secondary leakage of cerebrospinal fluid. A fascial graft should be used to repair any dural defect.

Fig. 606.—Laminectomy: The dura has been opened, exposing a leptomeningioma which is to be enucleated.

After-treatment.—If cystitis develops an indwelling catheter is used, with methylenamin and acid phosphate of sodium by mouth. If the urine is alkaline, lavage of the bladder with mercury oxycyanid, 1:4000 solution, is made night and morning. An enema is given every other evening. Great care and expert nursing are necessary to protect the insensitive skin, and to prevent pressure- and bed-sores.

The **mortality** of operations for benign tumors is about 10 per cent. Post-operative restoration of function depends upon the stage and type of compression. In the early stage with a benign tumor, complete or nearly complete restoration may be expected. If the pressure has existed for many months or years, only a partial restoration may occur, especially if there has been a deep indentation of the cord. Improvement is evidenced by the return of vesical and rectal control, followed by gradual return of muscular power and, finally, sensation. Sensory impulses are most likely to be permanently affected. Return of motor function, after a spastic paralysis has become flaccid, occurs rather rarely.

Rhizotomy (*Förster's operation*, 1909) consists of division, resection or ligation of the posterior nerve-roots, and has been used to relieve:

1. *Intractable pain*, as with the visceral crises of tabes; persistent and uncontrollable pain from brachial, intercostal, or sciatic neuralgia; or that following amputation, trauma, or malignant disease.

2. *Spasticity:* Rhizotomy is used to reduce the reflex arc, where there is spasticity due to lack of inhibition from the cortex, as in: (a) *Congenital spastic paraplegia* or diplegia (*Little's disease*). (b) *Acquired infantile spasticity* (infantile spastic paraplegia) which is usually a hemiplegia from encephalitis, sclerosis, cysts, or hydrocephalus. (c) *Lateral sclerosis* (spastic spinal paralysis of adults) usually occurring between the ages of twenty and forty. (d) *Multiple and disseminated sclerosis*. (e) *Tuberculous spondylitis* (Pott's disease), and (f) *tumors with marked spasticity*. In

multiple sclerosis, lateral sclerosis and myelitis, the operation is rarely indicated, as it seldom is useful in diseases of a rapidly progressive character or where there is insufficient mentality for co-operation in the after-treatment.

The operation consists of a laminectomy, with identification and resection of the posterior rami of the segments supplying the spastic muscles. As a rule, at least three contiguous roots should be resected. The operation has a mortality of about 10 per cent.

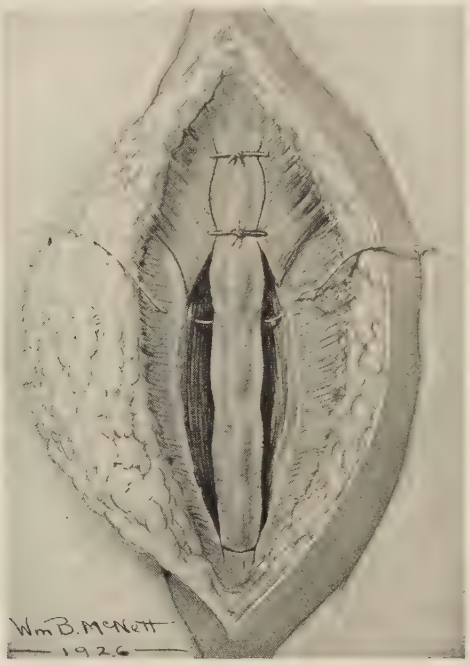


Fig. 607.—Laminectomy: The dura has been accurately closed by a continuous suture of fine silk carried in a small curved needle. The flap containing spinous processes is being sutured into position in such a way that it will not press upon the dura.

Extradural rhizotomy (Guleke, 1910) is also feasible. No sensory loss follows if not more than two consecutive roots are divided. For spasticity of the arm, the fifth, sixth, seventh cervical, and first dorsal may be sectioned; for the leg, most of the lower thoracic, lumbar, and sacral posterior roots are divided on both sides. For gastric crises, the sixth to eleventh thoracic roots, inclusive, are divided upon both sides.

Chordotomy (Schüller, 1910).—The division of the posterior columns of the cord is also used to relieve pain and spasticity by interrupting sensation and muscle-tone. For the lower extremities,

Fig. 608.—Frazier's chordotomy knives.

the posterior columns and cerebellar tracts are sectioned at the level of the tenth thoracic segment; and for both upper and lower extremities, at the level of the fifth cervical segment. Relief has especially followed section of the anterolateral columns of the cord, which carry pain and temperature sense. For the anterolateral columns, the incision begins $2\frac{1}{2}$ mm. anterior to the axis of the posterior root, and is carried forward $2\frac{1}{2}$ mm. and to a depth of $2\frac{1}{2}$ or 3 mm. (Spiller), the cord being rotated by traction upon the denticulate ligament. The chordotomy may be made with a von Graefe cataract knife, or by dividing the soft cord by introducing a fine silk thread (Frazier) with a

small curved needle, which is made to cut its way out by a sawing movement. For the relief of gastric crises, and for the relief of pain to the lower extremities, division at the fourth, fifth, or sixth thoracic segment is perhaps preferable to a lower level (Frazier). Diminution or loss of pain, and thermal sensation follows the operation. An annoying thermal paresthesia and urinary incontinence often follow the operation.

In meningomyelitis, and to relieve the exudate immediately following trauma (Krause and Taylor), a vertical incision is made in the posterior column, 3 cm. in length and 2 mm. in depth. This has been followed by great improvement where there is marked infiltration and swelling of the cord.

Allen's experiments on dogs show that contusions of the cord, more than sufficient to produce permanent paraplegia, are followed by recovery without paralysis if, within two hours from the time of injury, a median posterior incision is made in the cord. For spinal injury with immediate complete paraplegia, the cord should therefore, if possible, be exposed by laminectomy within two hours, and one or more vertical incisions, median or mediolateral, made in the cord to a depth of 2 mm. for a vertical distance of from 1 to 4 cm.

Resection of Sympathetic Nerves.—Hunter and Royle attribute the condition of *plastic tone* in muscles to innervation from the sympathetic system. With cerebral control removed, they believe the sympathetic produces spasm. Upon this basis they advocate division of the gray rami communicantes of the cervical sympathetic for spastic paralysis of the arm, and of the gray rami of the lumbar nerve for spasticity in the legs. The value of the method is in question.

In the **treatment of gastric crises** various other methods have been suggested, including: (1) *Stretching the solar plexus* (Jaboulay, 1900). (2) *Extradural rhizotomy* (Guleke, 1910). (3) *Extraction of the intercostal nerves* (Franke, 1910). (4) *Extradural ganglionectomy* (Sicard and Desmarest, 1912). (5) *Ligation of both anterior and posterior spinal roots* (Sauvé and Tinel, 1913). (6) *Peripheral vagotomy*, division of the vagus (Exner, 1911), and *resection of the vagus near the medulla* (Küttner, 1913). (7) *Alcoholic injection of the spinal posterior-root ganglia* (Chiasserini).

To inject a thoracic root, a needle is introduced 2.9 cm. to the side of the vertebral spine on a line opposite the middle of the spinous interspace. The needle should be at an angle of 45 degrees to the transverse line, and at an angle of $35\frac{1}{2}$ degrees to the cutaneous surface. The intervertebral foramen is reached at a distance of 3 to 5 cm., and the superimposed roots are about 2.5 cm. apart. About 1 c.c. of 80 per cent. alcohol is injected into each root (Sawyer).

Peripheral Operations to Relieve Cerebral Spasticity.—1. **Stöffel's operation** aims to restore equilibrium between the spastic and antagonistic muscles, by reducing the impulses to the spastic muscles through a division of one-third of the corresponding bundle in the appropriate peripheral nerve. The nerve supplying the muscle is exposed, the bundle desired located by the known topography and by electric tests with a fine bipolar electrode, and about one-third of the selected motor bundle divided. The operation also may be performed by dividing about one-third of the peripheral branches entering the spastic muscles. When properly done, the operation is followed by improvement but not complete relief. It should not be used where the spastic muscles are already atrophic or weakened, the antagonistic muscles completely paralyzed, or if the patient is mentally defective and incapable of persevering with the necessary postoperative treatment. Where the spasticity is diffuse or the lesion progressive, the operation is contraindicated. If improperly used, it may increase the paralysis. If too few fibers are resected, the spasticity continues. Three or more centimeters of the affected fibers should be excised to prevent regeneration.

2. **Transplantation of Motor Fibers** (Spitzy). About one-third of the involved motor fibers are transferred, to form an anastomosis with the nerve-supply of the antagonistic muscle-groups. The operation is of questionable value.

3. **Alcoholic injection of the nerves supplying the spastic muscles** (Schwab and Allison) arrests conduction and is a less severe operation than is resection of the corresponding nerves.

CHAPTER XXXVI

THE FACE

Embryology.—Branchial arches, separated by clefts communicating with the alimentary canal, appear early in fetal life. The first branchial cleft lies between the mandibular and hyoid arches. The mandibular arch consists of a superior maxillary portion, which becomes connected with its fellow through the interfrontonasal processes, and an inferior maxillary portion which unites in the midline, forming the mandible. Between these two is the buccal cleft, which is closed except for the aperture of the mouth. By the ninth or tenth week of fetal life, normally, the clefts have closed. Failure of closure results in *harelip, cleft-palate, oblique* and *lateral facial cleft,* or *macrostomia.* Rarely the orbital cleft stays open, and still more rarely the mandibular arch does not develop. The palate develops in two parts, formed by ingrowth of the palatal ridges backward, the union beginning anteriorly and not being complete until about the tenth week. If union does not occur, cleft-palate results.

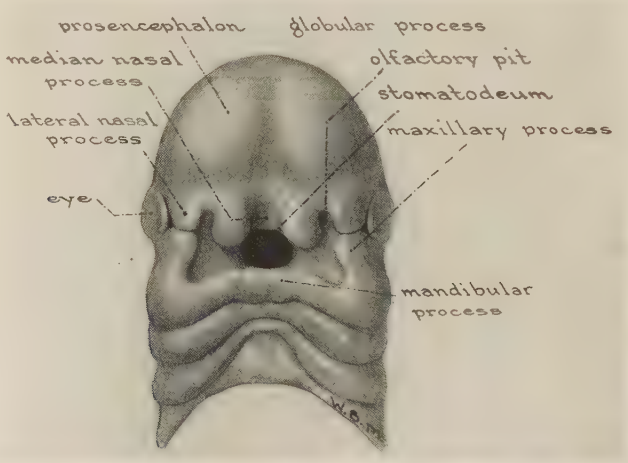


Fig. 609.—Development of the human face, showing the early embryonic processes (after His).

From the maxillary process are developed the maxillary bone and hard palate—except the intermaxillary portion (*os incisivum*)—the cheeks, and the lateral parts of the upper lip. From the frontonasal process arise the external nose, the ethmoid, vomer, columella, median portion of the upper lip (philtrum), and intermaxillary bone. In clefts of the lip and palate, the intermaxillary bone may project like a snout from the septum or tip of the nose, and may contain the germs of six incisors as in the carnivora. In no case is the cleft precisely like the Y-shaped one of the hare.

Congenital malformations result from fissural defects, chiefly between middle frontal, lateral frontal, and maxillary processes, and possibly from the pressure of amniotic bands.

Mouth.—(1) *Macrostomia*, large mouth, results from defective closure (between mandibular and maxillary processes). (2) *Microstomia*, small mouth, results from excessive closure of adjacent processes. (3) *Atresia* may result in the complete *phimosis* or imperforate mouth. (4) *Macrocheilia*, large lips, usually arise from lymphangiomatous or angiomatous change. (5) *Labial fistulæ* of small size occasionally occur near the middle of vermilion border. (6) *Harelip.*

Nose may rarely show: (1) Partial or complete absence. (2) Atresia of orifice. (3) Fissure or fistula of dorsum.

Cheeks.—*Lateral nasal clefts* result from defective union between the medial and lateral-nasal processes; *oblique facial clefts*, from defective union between lateral-nasal and maxillary processes. These clefts are partial or complete, and with or without associated coloboma of the lids. Coalescence of the lids and absence of upper lid are rare. *Auricular appendages* from misplacement of embryonic auricular cartilage occur in front of tragus and on cheek and neck.

Treatment of the various defects is plastic operation or prosthesis.

Jaws.—Congenital and developmental defects of the jaw include: (1) *Agnathia*, absence of the jaws (unusual). (2) *Micrognathia*, smallness of jaw. (3) *Prognathia*, protruding lower jaw, occurs as a development condition in

Fig. 610.—Congenital lateral facial cleft producing left-sided macrostomia.

Fig. 611.—Oblique facial cleft of the left side of the face with coloboma.

acromegaly. (4) *Polygnathia*, excess of jaws. (5) *Gnathoschisis*, cleft of the upper jaw, is frequent, as in cleft-palate. (6) *Opisthogenia*, defective development, follows ankylosis of jaws.

Anomalies in dentition include presence of erupted teeth at birth, premature and delayed eruption of teeth, supernumerary teeth, deformed and displaced teeth, impacted teeth, and the like.

Ears are not infrequently defective or deformed: (1) *Anotia*, absence of ears. (2) *Microtia*, small ears. (3) *Macrotia*, large ears. (4) Outstanding ears. (5) Deformities of component parts of the ear. (6) Stenosis and atresia of the meatus.

Treatment.—Otoplasty or prosthesis.

Harelip is the most common congenital defect. It involves the upper lip, usually upon the left side. *Lower lip* or mandible is rarely cleft and then only in the median line.

Etiology.—Harelip usually occurs in males. A defect in prenatal metabolism is suggested by the occurrence of harelip in lion cubs from mothers that have been fed meat without bone, and of spina bifida in tadpoles hatched in solutions containing certain concentrations of salt.

Varieties.—(1) *Single harelip* (unilateral), usually on the left side, is the most common. (2) *Double harelip* occurs in 10 per cent. of the cases. (3) *Complicated harelip* with associated cleft alveolus or palate, protruding premaxillæ (os incisivum), congenital fissure of cheeks, or other abnormality often occurs.

Complete harelip results from failure of union between the medial and lateral nasal processes and the maxillary process, and is characterized by a split of

Fig. 612.—Partial harelip upon the right side; the left side is more frequently involved.

Fig. 613.—Bilateral complete harelip with moderate protrusion of the os incisivum.

the lip into the nostril. *Incomplete harelip* varies from a slight notch at the vermilion border to a cleft extending almost to the nose.

Median harelip is very rare, and usually is associated with absence of the philtrum and often the columella, the premaxillary nasal septum; and may be associated with a median cleft of the nose.

Symptoms.—A complete cleft causes an indention and flattening of the nostril on the affected side, and deviation of the top of the nose and anterior septum toward the opposite side. The deformity is increased by contraction of the facial muscles, and tends to increase with age. Suckling and speaking are interfered with. Early correction is desirable for satisfactory feeding, more normal respiration, and the proper development of the face and jaws, as well as for the cosmetic effect.

Treatment.—Often the child is unable to nurse, and must be fed by a spoon or dropper. A large rubber nursing nipple that will fill the cleft, with a lateral orifice to be apposed to the tongue, is useful.

Operation.—Before operation the infant should have regained the weight at birth, show progressive gain under the feeding formula, and be free from respiratory infection. The preferred age is between two weeks and three months. Local anesthesia, with ½ of 1 per cent. procain, or the inhalation of ether or chloroform is used. The mucous surfaces should be sterilized by 20 per cent. argyrol or 1 per cent. mercurochrome. The steps of the operation are: (1) The wide *freeing of the lip* and flattened alæ of the nose from the alveolus and body of the maxilla, until the parts may be apposed without tension. (2) *Replacement* of the protruding premaxilla (which never should be removed) by sufficient submucous resection of the septum and fixation by silver-wire sutures. (3) *Paring of the edges* of cleft and suture of floor of nostril, correcting the distorted flattened ala. (4) *Accurate determination* by calipers, and marking on each side of the lip of points on the edges of the vermilion border to be apposed. (5) *Accurate approximation*, using interrupted sutures of 00 chromic catgut for the mucosa and horse-hair for the skin is important. (6) The wound should be *painted* with compound tincture of *benzoin* and exposed to the air, and a supporting bridge of adhesive plaster or other material used for two weeks. Alternate horse-hair sutures are removed on the third and sixth days. Straight splints are firmly fastened over the child's elbows for two weeks, so that the hands cannot be brought to the mouth. Only sterile food is used, given with eye-dropper or spoon, followed by gentle cleansing of mouth by boric acid solution on a small cotton swab.

Cleft-palate.—This may be *complete*, dividing both the soft and hard palate; or *incomplete*, involving the soft palate and part of the hard palate or alveolus, and is usually median with the nasal septum attached along the right side.

Symptoms.—In cleft-palate, food taken into the mouth enters the nose, and suckling is difficult or impossible; in phonation, the explosives T, D, P, B, F, V have the sound of M or N; the gutturals K and G, the sound of H. These faulty habits of speech, once acquired, are eradicated with great difficulty, even though the cleft be closed. It is, therefore, very important that the cleft be closed before the child learns to talk, and that the soft palate be flexible and competent to close the upper pharynx.

Operations.—Uranoplasty refers to plastic closure of the palate, staphylorrhaphy or staphyloplasty suture or plastic closure of the soft palate. 1. *Ferguson's, Langenbeck's, Sir Thomas Smith's Operation.*—The mucoperiosteum is divided well on the nasal side, separated from the bone, the strong attachment of the soft palate to the posterior edge of the bony palate cut through, the edges of the cleft in the soft palate and uvula split or pared, lateral relaxing incisions made mesial to the alveolar ridges, and the mucous edges united by fine silver wire, silk, and horse-hair, introduced by very fine curved needle. Relaxing and supporting sutures carried through thin lead-plates are sometimes used. This has been the most popular operation, the dropping or flattening of the arch of the palate enabling the apposition of the two flaps.

2. *Davies-Colley's, Lane's, Flap, or Early Operation.*—This must be performed before any teeth have erupted, or before the third month. A mucoperiosteal flap is raised, beginning over the lateral edge of the alveolus on the one side, reflected with the denuded surface toward the tongue over the gap, and partially buried in a pocket formed on the other side by raising the mucoperiosteum from the opposite bony palate, beginning at the edge of the cleft. The denuded bone and alveolus on the one side are soon covered by the outgrowth of epithelium. This operation, advocated for very wide gaps, is rarely used in this country. Obviously, if the flap sloughs, the patient is left in poor condition for a secondary plastic operation.

3. *Brophy's Operation.*—This aims to produce a bony instead of a membranous closure of the gap in the hard palate, in the early weeks of life while the bones are still soft. At a later time, the lips and soft palate are closed.

The child being in good general condition, free from thymus enlargement, and gaining weight, *the first operation* is performed between the second and twelfth weeks of life. The edges of the cleft are pared or split, the bones are forced together by the thumb and finger, aided by division of the

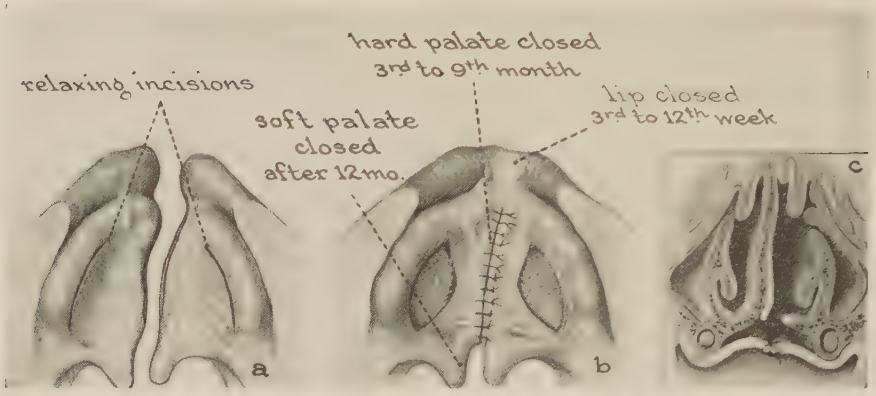


Fig. 614.—The Langenbeck or Ferguson operation for cleft-palate: *a*, Incisions. *b*, Relaxing incisions and sutures. *c*, The arch of the palate is lowered.

Fig. 615.—Cryer's periosteal elevator for the hard palate.

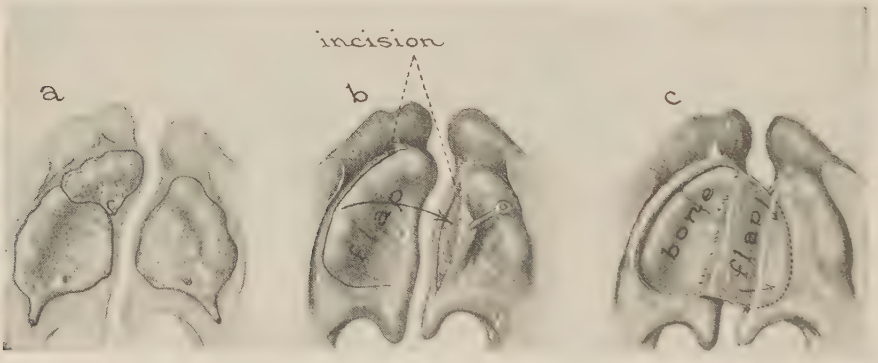


Fig. 616.—The flap, Davies-Colley, or Lane operation: *a*, Cleft hard palate showing bony framework. *b*, Mucoperiosteal flap outlined with pocket for its reception. *c*, Flap swung across cleft into pocket, for suture

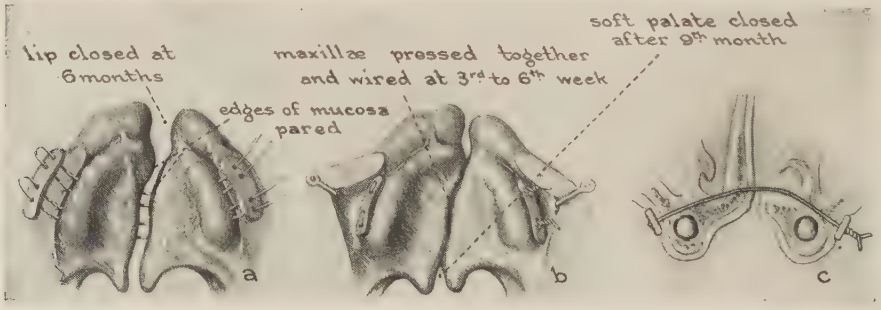


Fig. 617.—The Brophy operation for cleft-palate: *a*, Silver wires upon lead-plates carried across the gap above the alveolar ridge. *b*, Cleft closed by pressure upon the bones, and held by tightening the wires. The mucoperiosteal edges are pared so that union may occur. *c*, Cross-section, showing position of wires above the developing tooth germs.

malar processes through small incisions in the mucous membrane, if necessary. The bones are held in apposition by two or three mattress-sutures of 20-gauge silver wire, passed by a Brophy needle through the muco-alveolar angle above the palate and gums, twisted over 18-gauge perforated lead-plates to distribute the pressure on the alveolus. The mucous edges are united by silk, which is

Fig. 618.—Brophy's periosteal elevator for the hard palate.

removed in one week, and the plate and the wires in two to three weeks. Six weeks later, if the child is in satisfactory condition, the harelip is corrected; and at the age of sixteen to twenty-two months the edges of the soft palate are closed, the relaxing incisions being packed with iodoform gauze. Operation on the soft palate under sixteen months usually fails. The lip and palate in

Fig. 619.—Brophy's needle for passing wires through the superior maxillæ in cleft-palate operations.

infants should never be closed at the same time, as the mortality is high. Splints should be kept on the child's arms for three weeks; sterile liquid or very soft food given, the mouth cleansed with boric acid solution after each feeding, and 20 per cent. argyrol applied to the wound by a camel-hair brush, or dropper.

As a rule it is more satisfactory to close the lip before the age of three months. The pressure of the united lip gradually molds and narrows the cleft in the palate, which is closed by Langenbeck's method after the age of nine months in one or more operations. Fine silver wire, horse-hair, or silk should be used rather than catgut in operations on the palate.

A protruding *os incisivum* is moved back into place after the age of three months, the vomer is divided, compact bone resected, cancellated bone freshened to enable approximation, which is maintained by silver wire over perforated lead-plates. The wire is passed under the soft tissues, but not through bone. Interrupted horse-hair sutures are used for the skin.

To avoid defective hearing after closing the palate, a division of tensor palati which dilates the pharyngeal orifice of eustachian tube should be avoided.

Defects in the hard palate may result from congenital cleft-palate, or the sloughing and necrosis following operation, tumors, and especially syphilis. For very large defects, not suitable for operation, an obturator may be worn with a movable velum that is grasped and moved by the palatine muscles. By careful education, the patient may develop satisfactory phonation with such an appliance.

Double lip results from a redundant fold of mucous membrane within the vermilion border, or a condition seen in young men from enlargement of the labial glands of the upper lip at the sides of the frenum. A chronic edema or lymphangitis of the submucosa of the upper lip occurs in delicate children (*strumous lip, chronic induration of the lip*).

Treatment.—Associated cracks, fissures, or coryza should be corrected and, if indicated, a roborant treatment given. Persistent disfigurement may be overcome by a carefully planned excision of an ellipse of the redundant mucosa containing the hyperplastic glands.

Preauricular fistulæ are usually situated in the root of the helix; the opening may become occluded with abcess formation. The fistula results from aberrant coalescence of the six tubercles that form the pinna. Stammers reports 6 cases.

Treatment.—Injection with methylene-blue, excision, and suture.

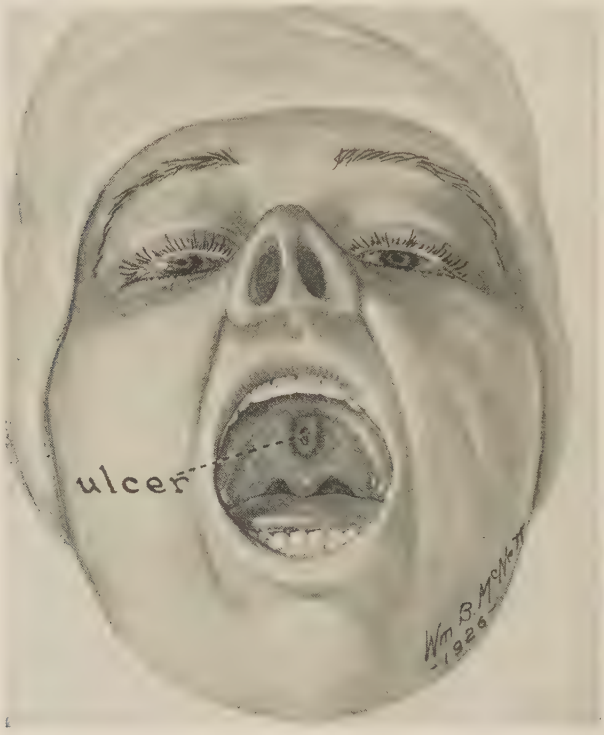


Fig. 620.—Gummatous perforation of the palate with saddle-nose and interstitial keratitis.

Traumatism.—(1) Contusions are characterized by marked effusion; (2) incised and contused wounds by hemorrhage; (3) lacerated and gunshot wounds usually are complicated by osseous injury.

The tissues of the face are very vascular, and resist infection, trauma, antiseptics, and tension from tight sutures.

Dangers.—(1) *Hemorrhage*, which may be severe, from the external maxillary, temporal, lingual, or internal maxillary arteries. (2) *Secondary hemorrhage* occurs from infection or necrosis of the arterial wall, and is to be treated by ligation of superficial arteries in continuity, or ligation of the (a) external carotid, (b) internal carotid, or (c) common carotid. (3) *Traumatic aneurysm* follows arterial injury. (4) *Involvement of accessory sinuses* and the cranial cavity; with emphysema, which is not serious, or meningitis, which often is fatal. (5) *Nerve injury* resulting in paralysis or neuralgia. (6) *Duct injury*, causing lacrimal

or salivary fistula. (7) *Complete detachment of portions of nose or ear*, which may be reaffixed by aseptic unstrangulated suture.

Gunshot wounds of the face usually are complicated by fracture. Mis-

Fig. 621.—Rhytidectomy. Operation for face lifting by excision of a portion of scalp. As the scar lies above the hair-line it produces no disfigurement.

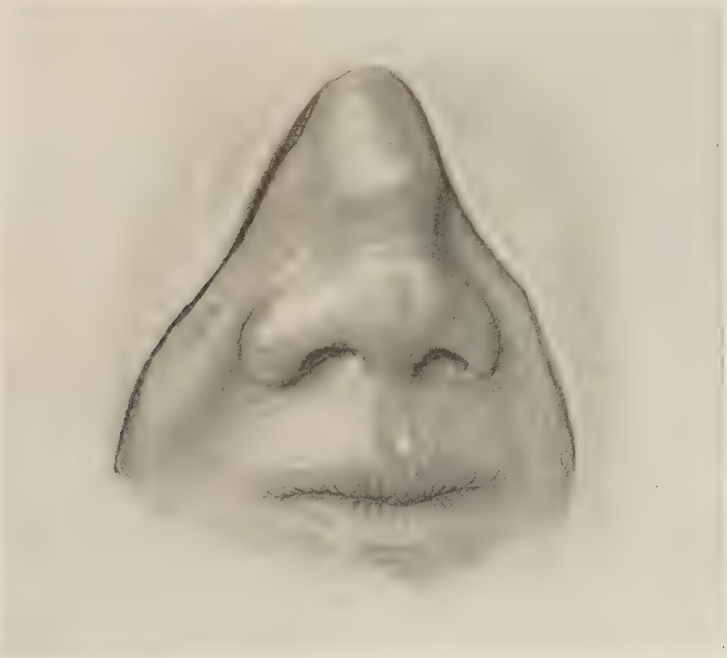


Fig. 622.—Saddle-nose from a submucous resection. The syphilitic saddle-nose involves the bony septum and the saddle is higher.

siles, particles of metal, wood, cloth, may be deeply buried in tissues and, if hard and sterile, are often retained without irritation.

Suicidal wounds through the mouth by high-velocity bullets produce terrific explosive effects. Laceration from fragments of bombs or high-explosive shells are often followed by death from hemorrhage or aspiration pneumonia.

Secondary Hemorrhage.—Ligation of the common carotid is required in certain cases where hemorrhage is from the base of skull, upper jaw, or great wing of the sphenoid.

Edema of the larynx may necessitate an immediate tracheotomy.

Wound infection and *sloughing* brings great risk of secondary hemorrhage. If the carotid has been ligated, the wound should especially be kept clean. In erysipelas, the surgeon may find it difficult to cope with secondary hemorrhage. Exposed vessels should be ligated in their continuity; the temporal or external maxillary, in their course; and for hemorrhage from the tongue, the lingual in the submaxillary triangle. Extensive manipulation or rough handling of the soft parts should be avoided.

Fig. 623.—Portion of costal cartilage introduced through an incision in a wrinkle line of the forehead for depression of the nose following a submucous resection. To raise the tip of the nose a piece of transplanted cartilage was introduced through a median incision in the columella.

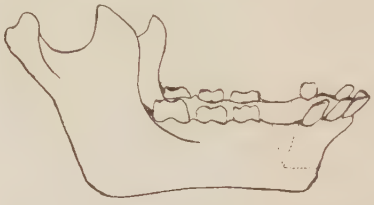


Fig. 624.—Deformity of mandible due to the traction of a scar from a burn of the neck. Hullihen's operation.

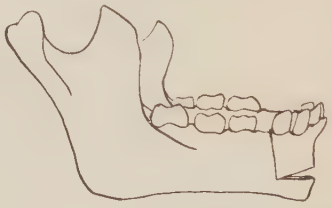


Fig. 625.—Diagram indicating the correction of the elongation of the jaw in Hullihen's case by the removal of triangular segments of bone. The vitality of the mobilized portion of the bone was maintained through vascular attachments to the lower lip.

For hemorrhage from deep wounds, packing and ligation of the external carotid are used. If this fails, the internal carotid or common carotid are tied as a last resort.

Neuralgia may come from involvement of a nerve in a cicatrix. Salivary fistulæ usually heal after cauterization. Enlarged lymph-glands are removed only when readily accessible, or when producing pressure on nerves or other important structures.

Burns of the face follow contact with hot bodies, flame, steam, caustic acids, and alkalies. The bones may be involved.

Treatment (see page 69).—The indications are to control pain, combat edema of the larynx, maintain asepsis, and prevent cicatricial contraction. Deep infected wounds cause denser scar-tissue than superficial aseptic wounds. Early skin-grafting should be used. Superficial powder grains are painted with a 1 per cent. solution of mercuric chlorid (Hebra) to produce pustulation, after which the grains may easily be removed.

Frost-bite and **chiblains** especially affect the ears and nose, and are to be treated as described on page 73. Residual chronic redness may be improved by punctate cauterization.

ACUTE INFECTIONS OF FACE

Varieties.—(1) *Furuncle.* (2) *Carbuncle.* (3) *Erysipelas:* (a) cutaneous; (b) cellulocutaneous or phlegmon. (4) *Anthrax* or malignant pustule: (a) carbuncle; (b) diffuse edematous type; (c) embolic anthrax of skin. (5) *Glanders* (acute or chronic). (6) *Noma* or *cancrum oris* (occurring in debilitated children).

Complications or sequelæ of acute infections include: (1) *Septic thrombosis* of nasal or orbital veins, lymphatics, cerebral sinuses; meningitis. (2) *Cutaneous gangrene* (especially over loose subconnective tissue). (3) *Phlegmon* (rare, but is dangerous as it may lead to meningitis or destruction of eyeball). (4) *Pneumonia*, embolic abscesses, and synovial infections. (5) Repeated acute infections may cause *myxedema-like thickenings of skin* from the lymphatic obstruction.

Erysipelas. — Infection occurs through inconspicuous abrasions, or complicates wounds or plastic operations involving the skin or mucous surface. High fever and delirium are common, but convalescence is often established in four to seven days.

Prognosis is guardedly favorable except in the debilitated.

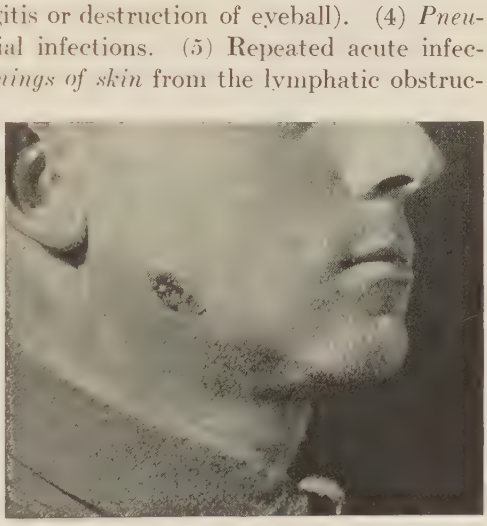


Fig. 626.—Anthrax pustule of five days' duration from shaving-brush infection with satellite bubo. Central gangrene and rapidly spreading edema is characteristic (Stokes).

Complications. — (1) *Infectious thrombosis* of nasal or orbital veins or lymphatics. (2) *Secondary intracranial infection.* (3) *Cutaneous gangrene* (noma). (4) *Phlegmon* is unusual. *Orbital phlegmon* is rare, but carries the danger of meningitis or destruction of the eyeball. (5) *Metastatic pneumonia*, pericarditis, endocarditis, abscesses, or synovial infection. Erysipelas may repeatedly recur and cause myxedema-like thickening of skin from lymphatic obstruction.

Anthrax is contracted from the hair, hides, or tissues of animals with splenic fever. Inoculation occurs by the finger-nail, the sting of flies, by shaving-brushes, and tooth-brushes. (1) The *circumscribed carbuncular form* is the most common. Thirty per cent. of all cases involve the face, excluding the forehead;

90 per cent. the face, neck, and lung. (2) *Diffuse edematous form* is not infrequent. May rarely be associated with (3) *embolic anthrax*, causing discolorations, papules, or pustules of the skin.

Symptoms.—(1) Red, very itchy spot. (2) Minute bluish-red vesicle in twenty-four to forty-eight hours, containing serohemorrhagic blood with bacilli. A dark crust forms, serous blood oozes from under the crust, and the inflamed, reddened, swollen tissues rise like a wall. (3) A dark central slough forms, which may spread. An edematous swelling widely surrounds the gangrenous area, and shows numerous vesicles. Fever accompanies pustulation in one-fourth of the patients. In the severe types there is evidence of general infection, with diarrhea, delirium, somnolency, and fever persisting until death.

Treatment.—(1) *Prophylaxis.* (2) *Absolute rest*, protection, and tonics. Avoidance of local traumatism (see page 153).

Glanders.—The nodules and ulcers develop on mucosa of the nose, mouth, conjunctiva, or occasionally on the skin.

Symptoms.—A nodular inflammatory infiltration is succeeded by pustules, and then eroding ulcers with undermined and sinuous borders and extensive tissue destruction. A diffuse phlegmonous and fatal form, resembling severe facial erysipelas, is rare. There is a tendency to blood dissemination and multiple abscesses in internal organs, muscles, marrow, and locally a suppurative lymphangitis and adenitis.

Prognosis.—(1) *Acute type* runs a rapidly fatal course with high fever. (2) *Subacute type*—one-half of the patients recover. (3) *Chronic type*—the chronic ulcers of the face may resemble lupus, syphilis, or actinomycosis, and may be difficult of diagnosis (see page 172).

Tetanus.—Tetanus hydrophobicus, tetanus facialis, tetanus paralyticus.

Symptoms.—The acute form develops within a few days of inoculation and usually is fatal. There is spasm of pharynx, glottis, tetanic twitching of muscles of face and of mastication, and paralysis of the facial nerve. The muscular spasm may extend downward to neck, trunk, and extremities.

The spasms may be limited to a certain cranial nerve, especially the facial nerve. The paralysis never involves the motor trigeminal region. The side of the face infected shows the greatest spasm. Fever usually is absent. Death results from convulsive spasm of diaphragm, or from cardiac paralysis. Subacute or chronic types last from seven to twelve weeks, and give a better prognosis.

Diagnosis may be difficult in chronic forms, especially if a wound and paralysis are both absent. Trismus occurs in many inflammatory affections of the face, but the association of facial paralysis with trismus as a normal complication suggests facial tetanus.

Treatment.—Intrathecal injections (in *cisterna cerebellomedullaris*) of antitoxin (see page 150).

CHRONIC INFECTIONS

Tuberculosis.—**Varieties:** (1) Lupus. (2) Tuberculosis cutis (ulcerative). (3) Verrucose or papillary excrescences (postmortem wart, anatomic tubercle). (4) Scrofuloderma (ulcers or sinuses from lymphatic disease). (5) Osseous (especially of the malar bone).

Lupus and Tuberculosis Cutis.—Etiology: Age, ten to fifteen years; female sex. Three-fourths of the cases occur upon the face, and 38 per cent. of these involve the nose. In two-thirds there are other tuberculous lesions in the body.

Varieties.—1. *Non-ulcerative:* These are disseminated, very chronic, pin-to pea-size, brownish-red nodules, occurring especially at edges of nostrils, on cheek, chin, and forehead; not obliterated by pressure. Old areas show cicatrization with central, thin, whitish, shiny, soft scars and, at the periphery, recent nodules and infiltration with the spread of the disease. The process may continue for years without ulceration, and spread over entire face.

2. *Ulcerative Type:* Soft undermined ulcers develop with gnawed edges, dirty bases, and adjacent small, obscure, brownish nodules, on the lips, at angles of mouth, and nose that may invade the periosteum and bone. The ulcers become covered by a thick hard crust with a tendency to bleed. The process is aggravated by the associated mixed infection.

Fig. 627.—Primary tuberculous lesion of the cheek. A satellite adenopathy from the tuberculous chancre may be found at a considerable distance. Apple-jelly tubercles are to be recognized under glass pressure (Stokes).

Fig. 628. –Sarcoid infiltration of the face of the subcutaneous or Darier-Roussy type. This condition was relieved by eighteen arsphenamin injections. Sarcoids are tumors or plaques of tuberculoid structure not subject to ulceration or erosion, and respond to arsphenamin, but less readily than does syphilis (Stokes).

3. *Verrucose type* is characterized by papillary excrescences.

4. *Gumma tuberculosum*, a soft nodular infiltration, occurs in the connective tissue. The overlying skin discolors, breaks down with discharge, leaving persistent, undermined ulcers with fungous granulations or sinuses. This type is secondary to tuberculosis of bone or lymph-nodes.

5. *Adenitis on face* usually involves: (a) Commissural lymph-nodes in front of masseter and middle of line between mouth and lobule of ear, and (b) the parotid lymph-nodes.

6. *Osseous tuberculosis* is often associated with tuberculosis of the calvarium and bones of the orbit. If neglected, the entire zygomatic bone may be destroyed. Discharging fistula, ectropion, sequestration, deformity, and scar result.

Diagnosis.—In lupus vulgaris the adjacent skin shows miliary tubercles

(*apple-jelly nodules*), usually seen by pressing a glass slide over the periphery of the extending tuberculous process. Lupus should be differentiated from: (1) Hypertrophic syphilide. (2) Blastomycosis. (3) Pyogenic or vegetative granulomas. (4) Espundia—a tropical lesion, probably a leishmaniasis. (5) Fungoid lesions as bromoderma and ioderma, yaws. (6) Carcinoma actively attacks the bone and cartilage. Lupus vulgaris rarely destroys the septum or alæ without involvement of the skin of the cheek and malar prominences. Tuberculosis of the face may begin at any age. The borders of an epithelioma show rolling and curling. In espundia the palate is involved.

Treatment.—(1) General roborant. (2) Local cleanliness. (3) Radiant energy, ultraviolet and Roentgen rays. (4) Tonics, creosote or guaiacol intrenally, with forced feeding. (5) Tuberculin. (6) Local curetting, cauterization, excision, skin-grafting plastic operation. Recurrence is not usual after an extensive plastic operation.

Heavy roentgenism should not be used, as an irradiation scar and a tuberculous scar are most prone to become epitheliomatous. Radium has a greater output of soft rays, produces surface reaction in a short time, and may occasionally be of benefit. The Kromayer lamp may be used daily with systematic irradiation. It is important to have an air-cooled burner and to make pressure upon the skin, to render it anemic and more easily penetrable by the rays. Locally the curet and the acid nitrate of mercury, used with care, are of value, and it is to be remembered that improvement at times follows moderate doses of neo-arsphenamin.

Fig. 629.—Chancre of the upper lip (Stokes).

Syphilis.—1. *Cutaneous eruptions:* (a) *Rhagades* occur in children from congenital syphilis as a fissured eruption about the angles of the mouth and alæ. (b) *Chancre*, inoculation usually occurs on upper lip, chin, cheek, in young adults through impure contact, razor cut, abrasion or fissure. (c) *Secondary eruption*, characterized by multiple painless ulcers with undermining scalloped border, wash-leather base, adjacent dusky red tissue.

2. *Gumma:* (a) *Subcutaneous.* (b) *Periosteal*—usually on frontal bone with suppuration. (c) *Osseous*—as a destructive necrosis of nasal bones and cartilage with *saddle-nose* from inherited or acquired syphilis, or a necrosis of frontal bone with ulceration and sinus formation.

Diagnosis.—*Syphilis* attacks the angles of the nose, mouth, forehead (*corona veneris*), and frontal bone. *Lupus*, the skin of upper lip, nose, cheeks, bony margins of orbit (zygomatic bone). The ulcers of lupus are soft, chronic, of slow evolution, shallow, have slightly elevated edges, pale edematous granulation tissue, with characteristic minute nodules at periphery, healing with a soft, white atrophic scar. Ulcers from gumma may be spread rapidly, have serpiginous serrated outline, steep, thin undermined borders, and at times an undermined base and a turbid serous discharge. They heal with depressed, dusky red or, later, a white scar. Lupus may also attack the cartilaginous nasal septum.

Treatment.—Local cleanliness, iodid of bismuth paste. General treatment by iodids, mercury, arsenic, and bismuth.

Actinomycosis usually develops from mouth and mandible with: (1) *Indurated areas*, chronic cold abscesses, and sinuses of cheeks, neck, and temples. The lips and lids are seldom involved. (2) *Pustular eruption* of skin (rare).

Treatment.—Intermittent iodization, *x*-rays, surgical curetment, or excision.

Rhinoscleroma.—Involves the lower part of nose, adjacent skin, occasionally the pharynx and larynx, with painless, diffuse, circumscribed firm nodules and, at times, slight ulceration.

Treatment.—Injections of antiseptics. *x*-Rays, radium, excision, actual cautery, curetment. Tracheotomy or skin-grafting may be necessary. Complete extirpation is difficult, and recurrence is usual.

Fig. 630.—Typical nodulo-ulcerative syphilid with negative Wassermann of ten months' duration. It is unilateral, indurated, indolent, with normal surrounding skin, no metastatic nodule formation, no diffuse inflammatory areola. The scar is non-contractile, the lesion is spreading, fan-shaped (Stokes)

Fig. 631.—Syphilitic saddle-nose previous to correction.

Fig. 632.—Correction of saddle-nose by a graft of costal cartilage introduced through a wrinkle line of the forehead. *Operation.*—(*a*) Vertical incision $1\frac{1}{2}$ cm. long in wrinkle line at inner edge of left eye brow. Blunt-ended scissors introduced and skin separated from framework of nose to tip. (*b*) Section of seventh right costal cartilage removed, contoured, and carried through incision to tip of nose, raising unsightly depression. Wound closed with fine horse-hair, thoracic wound with silkworm-gut.

Leprosy is characterized by lepromes, furrowed brow, and anesthesia, and is to be treated by cleanliness, protection, and chaulmoogra oil.

Mucous cysts of lower lip are to be treated by cutting away the overlying wall, and cauterizing remainder.

Echinococcus cysts (rare in United States) occur in the temple, cheek, the

muscles of mastication, or in the orbit, and are diagnosed by examining the contained fluid, and treated by complete extirpation. *Cysticercus cysts* are rare and develop in the eyelids.

Rhinophyma (Potato Nose, Burgundy Nose).—A dark red, lobulated, soft, nodular, painless enlargement of the nose, with enlarged sebaceous glands, occurring in middle-aged or elderly men.

Treatment.—The nose is contoured without injury to the cartilage by removing the external layers. Epithelization usually promptly occurs from the deep glands or skin margins without grafting.

Cornu (Horns).—**Varieties:** (1) *Sebaceous horns* arise from the epithelial lining of sebaceous cysts, show longitudinal fibrillation, and are most common on the scalp. (2) *Wart horns* develop from verrucæ. (3) *Cicatricial horns* usually are laminated, and are rare. They originate in a scar, as that from a burn. The base may ulcerate and a carcinoma develop. To prevent recurrence the base should be excised. A calcified epithelioma may be mistaken for a horn.

TUMORS OF THE FACE

Fibroma.—1. *Neurofibroma:* Fibrous growth connected with nerves of cutis or subcutis or with the main nerve-trunks. The overlying skin is normal, pigmented or hairy (*rat-skin*): (a) *Flat pigmented nevus* (congenital). (b) Painful *subcutaneous tubercle.* (c) *Fibrocellular tumor* (*fibroma molluscum, dermatolysis, elephantiasis of skin*) consists of multiple soft fibromas of skin, forming nodules, pendulous folds, or large pediculated masses. (d) *Neurofibromas* of nerve-trunks, and plexiform fibromas. (e) *Neuropathic papillary fibromas* are present at birth or develop in early life, and are characterized by hyperplasia of connective tissue of the cutis and overlying papilla. They are unilateral, and may closely follow the nerve-trunks.

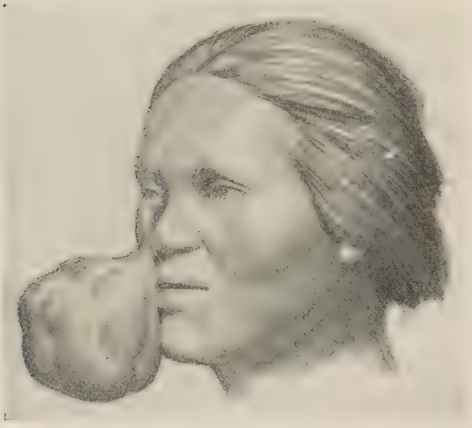


Fig. 633.—Pediculated fibroma of the right cheek (Dr. Harding).

2. *Keloid,* a fibrous overgrowth from scars, occurring especially in negroes.

3. *Fibroma* at root of nose is rare, but important, as it may overlie a meningocele and communicate with the cranial cavity.

Treatment.—Excision and suture. For large nevi and elephantiasis excision is difficult, the tissues being friable and vascular, while the large area of involvement may necessitate skin-grafting or plastic operation. Multiple operations are often desirable. Keloid frequently recurs after excision. Occasionally it disappears under antisyphilitic treatment, although evidently not a syphilitic lesion. Radiation is at times effective.

Lipoma is infrequent, only 2 per cent. involving the face. It may originate in the subcutaneous or submucous tissues, especially from the cres-

centic sucking pads about the anterior edge of the masseter. In the parotid region outlying lobules from fatty masses in the neck occur. Lipoma also grows from the subcutaneous fat about the lower jaw, chin, but seldom from the lips, bridge of nose, or under eyelids. Congenital lipoma occurring as fibrolipoma or angiolipoma is rare. The skin overlying the lipoma may be normal, thinned, or finely telangiectatic.

Diagnosis is to be made from chronic abscesses, cysts, lymphangiomas, angiomas, aneurysm, by the history of uniform slow development, incompressibility, lobulation, absence of inflammation, translucency of the part, and negative result of exploratory puncture.

Treatment.—Excision, if the growth is unsightly, by incision through skin or mucosa, avoiding the parotid duct and facial nerve. Angiolipoma and large tumors of the cheek in the parotid or facial angle are often difficult to remove, and may best be excised in sections through multiple incisions in order to protect the branches of the facial nerve.

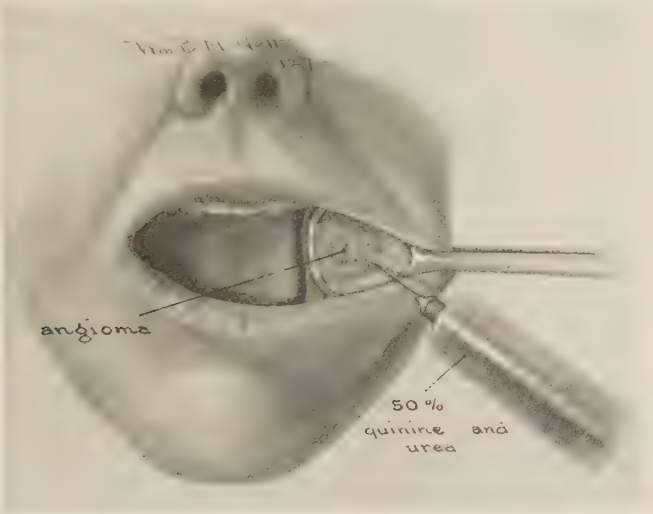


Fig. 634.—Injection of angioma of the cheek with a 50 per cent. solution of quinin and urea.

Angioma.—A. **Hemangioma** may be (1) congenital, (2) traumatic, or (3) idiopathic. It forms an elastic, compressible, flat, rounded, or lobulated growth.

Site.—Angiomata involve the skin, subcutaneous tissues, mucous membrane, and gums; the order of frequency being: Buccal, frontal, labial, nasal, aural, palpebral. Two-thirds of all angiomata involve the face, and two-thirds occur in females.

1. *Cutaneous angioma* (*angioma simplex*): (a) *Nevus araneus*, papillary varix with radiating branches (*spider cancer*). (b) *Nevus vasculosus* (*nevus angiectodes, port-wine mark, mother's mark, birth-mark*) consists of dilated veins and capillaries, and is usually congenital.

2. *Subcutaneous plexiform angioma.*

3. *Angioma venosum racemosum.*

4. *Angioma arteriale racemosum* (*cirsoid aneurysm*) may be congenital or traumatic.

Symptoms.—*Cutaneous type:* Skin smooth, thickened, elevated; with an irregular, elastic, lobulated, or pedunculated tumor. May be bright red (*nevus flammeus*), or bluish red (*nevus vinosus*), or without coloration of skin in the subcutaneous form. At times nevi contain phleboliths. At birth they resemble fleabites, but may spread rapidly, involve most of the face, and by pressure destroy soft tissue, cartilage, and bone (especially the cavernous type). The mass enlarges on emotion, as in the case of King Leopold. The *arterial types* pulsate. Spontaneous retrogression, hemorrhage, or inflammation often occur at dentition. The angioma may extend to the mucous membrane of the cheeks and gums. Pain occurs from pressure on nerves. If deep seated, there is no discoloration of the skin. In the orbit the angioma may cause *evacuatio orbitæ.*

Prognosis.—Angiomas may undergo retrogression, extension, inflammation, hemorrhage. In the superficial types the hemorrhage is easily controlled.

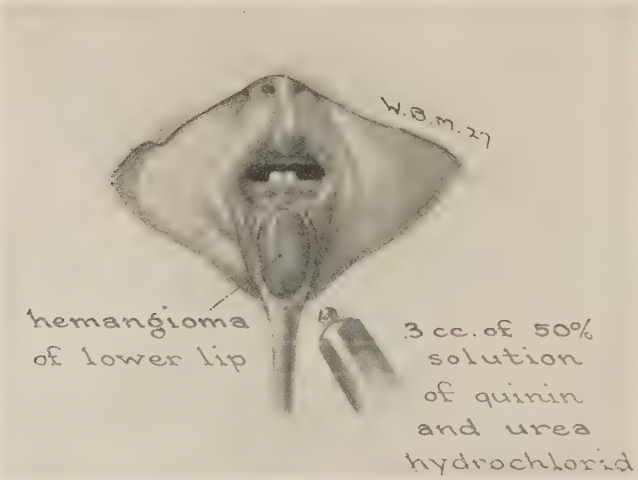


Fig. 635.—Hemangioma of the lower lip, mucous surface. Injection of 0.3 c.c. of a 50 per cent. solution of quinin and urea hydrochlorid, after the application of a clamp to avoid diffusion into the general circulation.

Treatment.—1. *Superficial Type:* Freezing by carbon-dioxid snow is useful, as is cauterization by fuming nitric acid, trichloracetic acid, electrolysis, the electric cautery, or the application of radium.

2. *Deeper Types:* Injection of ½ to 2 c.c. of 30 to 50 per cent. quinin and urea solution by hypodermic needle is very effective, as is also the injection of boiling water. Caution is necessary in making these injections in infants.

Electric coagulation, ligation, and excision are useful in certain types. Angiomata in the orbit should be destroyed early in order to save the eye.

In cirsoid aneurysm a large flap containing the vessel is raised, and separated from the bone by gauze. At a second stage the vessels are ligated or excised, and the flap replaced.

B. **Lymphangioma.**—**Varieties** include: (1) *Telangiectatic* (lymphangioma simplex, telangiectasia lymphatica), (2) *cavernous* (lymphangioma cavernosum), or (3) *cystic* (lymphangioma cysticum). They contain clear or

milky lymph. Congenital forms occur in the tongue (*macroglossia*), in lips (*macrocheilia*), and in cheeks (*macromelia*); together with a cystic type in the skin (*nevus lymphaticus*), and neck (*hygroma*). *Simple lymphangiomata* include pigmented nevi, lentigines (freckles), ephelides, and verruca carnæ (fleshy warts). They consist in part of hyperplastic lymphatic endothelium.

Symptoms.—Lymphangiomata are soft or rather firm and somewhat compressible when in the cutis or subcutis or entire thickness of cheek. By pressure they may interfere with development of the jaws. The skin is normal or slightly bluish from the underlying cyst, and adherent or non-adherent. Acute increases and decreases of size occur from infection.

Diagnosis is to be made from hemangioma, lipoma, or cyst.

Treatment.—A lymphangioma occasionally withers or disappears from inflammation. Excision is difficult except when the mass is small, and after operation there is danger from continued lymph-drainage and infection. Injections of quinin and urea, boiling water, alcohol, or iodin may be used, or at times partial ligation. From recurrent inflammations (erysipelas, acne rosacea, etc.), lymphangiomatous tumefactions of the skin (as elephantiasis, rhinophyma) occur, which are to be treated by injections, cauterization, or wedge-shaped excisions. Hemorrhage often is difficult to control during attempts at excision.

Sarcoma is rare at birth, but develops during early life or later years: 1. *Cutaneous soft sarcomatous warts* are usually light brown, bluish, or black. They grow rapidly, and ulcerate superficially; adjacent, pigmented satellites develop, the lymph-nodes enlarge, and there is early metastasis and death.

2. *Subcutaneous sarcomas* develop from fatty cushion of cheek, connective tissue of orbit, periosteum, bone, or parotid lacrimal gland, as a rapidly growing, solid, nodular, or rarely a fluctuating or pulsating tumor. Rapid growth justifies immediate operation in any doubtful tumor.

Treatment.—Radium, *x*-ray, or free extirpation. In the orbit, Krönlein's temporary resection of the external orbital wall is useful for exploratory purposes. In advanced cases *evacuatio orbitæ* is necessary, with extirpation of the conjunctiva and suture of lids.

Endothelioma develops in the subcutaneous tissues of lower lid, cheek, upper lid, or nose, as slow-growing, encapsulated, mobile masses with overlying normal skin. It occurs at all ages and may be hard, soft, or fluctuating, sessile, fungoid, or slightly nodular, and may ulcerate. Lymphatic involvement is unusual and the tumor is only moderately malignant.

Epithelial Tumors.—**Atheromata** (*sebaceous cysts*) are less frequent and smaller than on the scalp, and chiefly involve the cheeks about the eyelids, and are subject to inflammation, calcification, and carcinomatous degeneration.

Treatment.—Extirpation of the sac under local anesthesia.

Dermoids occur near the outer or inner canthus, glabella, bridge of nose, naso-orbital furrow, and in the intermaxillary cleft from the invagination of ectoderm. On the nose they may project under the nasal bones and into frontal sinus. The overlying skin is normal, inflamed, or may show dermoid fistula with projecting hairs. Suppuration frequently occurs, but cancerous degeneration is rare.

Treatment.—The sac and fistulous tract should be completely excised.

Adenomata develop from the sebaceous and sweat-glands as small, usually circumscribed, multiple, nodular, or warty growths, which may become malignant, and should be excised.

Carcinoma of the Face.—One-third to one-seventh of all carcinomas attack the face, and two-thirds of all tumors of the face are carcinomatous. In order of frequency, the lower lip, nose, cheek, eyelids, upper lip, and chin are involved.

Varieties.—A. *Superficial* (from rete): *Squamous-cell carcinoma, prickle-celled carcinoma*, hornifying cancroid, adult type acanthoma, Paget's disease.

B. *Deep* (from sebaceous or sweat-glands): (1) *Basal-celled carcinoma (rodent ulcer)*: A reticulated epithelioma developing from the malpighian layer of the skin. (2) *Adenoid carcinoma* (on the lip): (a) Papillary or fungating epithelioma, of slower growth and less malignant. (b) Ulcerating or indurating epithelioma—the more malignant form. (c) From mucosa spreading to skin. Rodent ulcers grow slowly for many years, with a tendency at times to imperfect healing, without involving

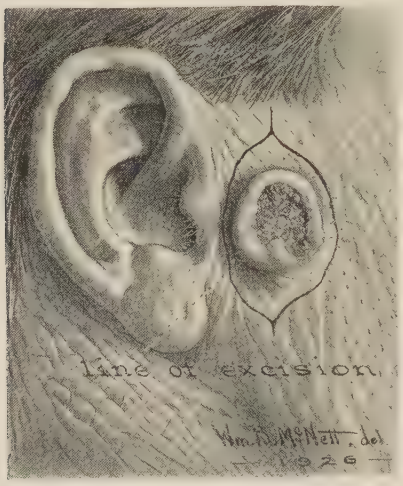


Fig. 636.—Squamous-celled epithelioma of the cheek showing characteristic raised, indurated, rolled, and everted borders. A wider excision than that indicated should be used.

Fig. 637.—Epithelioma of the lip at the stage when wide excision is curative and produces little deformity.

the lymph-nodes, but gradually destroying the soft and hard tissues. Types (a) and (c) tend to early involvement of lymphatics and internal metastases.

Etiology.—The growth is favored by: 1. *Advanced age*, forty to sixty years. (2) *Rural life.* (3) *Uncleanliness.* (4) *Irritation*, exposure: (a) Clay pipe; (b) benign tumors (atheromas, dermoids, papillomas, horns, adenomas); (c) inflammation (erysipelas, eczema, chronic ulcers, lues, tuberculosis, burns); (d) scars, certain skin diseases, dermatitis pigmentosa, seborrhea, leukoplakia.

Symptoms.—Ulcer, or scabby, fungous, or papillary growth. The ulcer has thick, swollen, indurated, everted edges, and sloughing crater-like center. The more serious squamous-cell epitheliomas begin at the mucocutaneous junction. Basal-celled growths occur chiefly in the middle third of the face, and spread to the mucous membrane from the cutaneous surface. There are four types, the *nodular*, the *ulcerative*, the *cicatrizing*, and the *cystic*.

Prognosis.—*Superficial types:* After free excision or destruction 70 to 90 per cent. remain well after three years; *deep types*, 20 to 60 per cent. If extensive, or in cartilage, the prognosis is bad. For advanced inoperable cases the

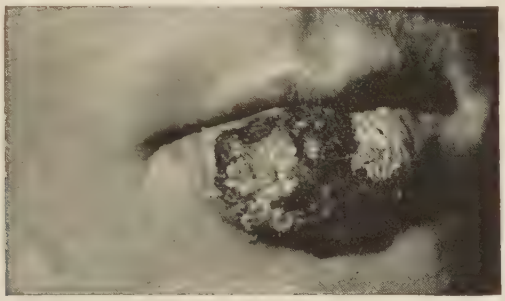


Fig. 638.—Epithelioma of the lower lip in a man of twenty-six (Stokes).

internal use of morphin, local use of filtered radium in heavy doses, deodorants, and the actual or electric cautery have been advised. Care should be taken not to increase the suffering of the patient by the treatment used. The rodent ulcer or basal-celled carcinoma usually slowly progresses, despite treatment, and

Fig. 639. -Epithelioma of the lower lip. Wide resection and free removal of lymph-glands of the neck is desirable.

without metastasis for ten to thirty years, and may finally cause death by invasion of the skull.

Treatment.—(1) *Prophylactic treatment*, or removal of areas of irritation. (2) *Early* and *complete removal*, or destruction of involved areas, including 1 to

2 cm. of adjacent tissue. For superficial types, radium, *x*-ray, caustics, or Marsden's paste. A thorough surgical excision may necessitate a secondary plastic operation. (3) In types (b) and (c) prompt and *thorough excision* of all tributary lymphatics is important.

For *epithelioma of the ear* or in cartilage the Roentgen ray or radium should not be used. Diathermy or the cautery may be tried, but the resulting ulcers are painful and difficult to heal.

The melanosarcoma does not respond to radium therapy. The sarcoma of Kaposi may be treated by the cautery, or by electrocoagulation.

CHAPTER XXXVII

THE JAWS

Congenital Anomalies.—*Cleft-palate* and *cleft alveolus* have been described with the defects of the face.

Hypoplasia of the mandible (*bird-face, receding chin*) results from disuse of the jaw, as in ankylosis.

Fig. 640.—Inferior prognathism.

The appearance of the patient is improved by implanting a graft of cartilage or fat under the skin of the chin.

Inferior prognathism may be due to an obtuse angle at the junction of the body and ramus of the mandible, or to overgrowth of the lower jaw.

Fig. 641.—Reduction in size of a prognathous jaw by the bilateral section of Bollin, Angle, and Blair. The operation may be done from beneath the jaw and mucous membrane without entering the mouth.

Treatment.—Reduction in size of the lower jaw by a bilateral resection of the body of jaw (Bollin, 1908). If two teeth have been extracted, this may be done

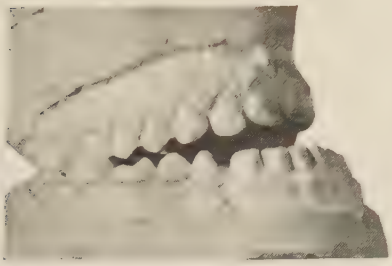


Fig. 642.—Inferior prognathism, showing malocclusion before division of the rami.

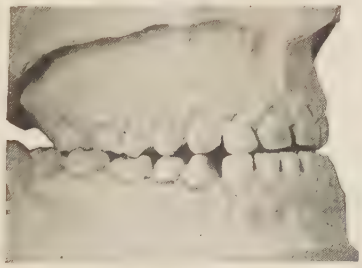


Fig. 643.—Inferior prognathism, showing occlusion after division of the rami.

from without, without entering the mouth. If the angle of the lower jaw is at fault, the jaw may be pushed back into position after dividing the ramus (Babcock, 1911). These operations should only be undertaken in co-operation with a

skilled dentist, and after a careful study of the occlusion of the patient's teeth. After the operation the jaws should be fastened together by wiring or other effective measure.

Ankylosis of Jaws (Lockjaw). -The inability to separate the jaws from mechanical cause. Varieties are: *Bony, fibrous, spastic, functional, unilateral,* or *bilateral.*

Etiology.—(1) *Developmental, congenital,* or *agenetic,* as in micrognathia. (2) *Arthritic,* from infection of scarlet fever or other exanthema, wounds, gonorrhea, rheumatism, arthritis deformans. A destructive arthritis occurs, which is followed by fibrous or bony anklyosis. (3) *Myogenic,* from: (a) Muscular spasm (*trismus, spastic ankylosis*) of tetanus, eruption of third molar, periostitis, parotitis, local abscess, phlegmon, hysteria, or neurosis; or (b) muscular destruction following injury or severe infection. (4) *Dermatogenic,* from destruction and replacement of skin or mucous membrane of the cheek by scar tissue, as after burns, injuries, noma, and other destructive infections.

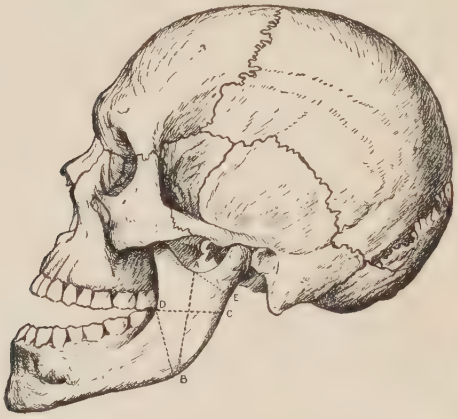


Fig. 644.—Diagram showing malocclusion and prognathism. The dotted lines indicate the possible lines of section in correcting the deformity by division of the ramus.

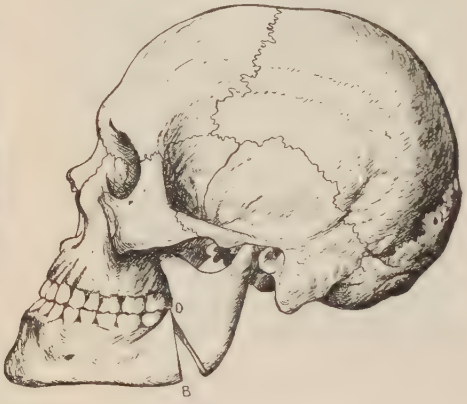


Fig. 645.—Diagram showing the result of correcting the deformity by division of the ramus along the line *D–B*. This line of section divides the inferior dental canal, but as it is below the more important muscular and ligamentous attachments, it permits a greater mobility than the higher line of section.

Symptoms.—Inability to move the mandible, to masticate or enunciate properly. Hypoplasia of mandible (*bird-face*), faulty eruption of teeth in the young.

Diagnosis.—In unilateral bony ankylosis, the slight spring of the chin is toward the side of the ankylosis. The radiogram is of value in showing the bony changes.

Treatment.—Extraction of teeth is nôt necessary in order to feed the patient.

1. *Arthritic Type:* (a) *Fibrous ankylosis* should be treated by the gradual separation of the jaws by a wooden or vulcanite screw or a padded metal separator. If this is not effective, the treatment is that for bony ankylosis. (b) *Bony ankylosis* should be treated by an arthroplasty. Through an angular

incision, a section of the zygoma is temporarily turned down. The condylar process should be removed (best by a revolving burr), the jaws freely separated, the gap filled with a pedicled flap of temporal muscle or a free fat transplant, and the wound closed. The functional results from this operation are excellent, despite years of disuse of the jaw.

2. *Myeloplastic* and *dermatogenic ankylosis* should be treated by stretching or dividing the contracted or fibrous muscle. If the skin or mucous membranes are defective or inadequate a plastic operation is useful. The Esser inlay graft is used for a defect in the mucous membrane.

Myeloplasty, usually by a pedicled flap from the neck, temple, or forehead, may be used to replace the skin of the cheek.

Fig. 646.—Oral screw for separating the jaws.

Dental caries is due to bacterial invasion of a tooth, aided by erosive acids formed by the bacterial decomposition of adherent carbohydrate foods (lactic acid) or mineral acids given as medicine (hydrochloric acid, tincture of chlorid of iron). It is favored by heredity, rickets, pregnancy, carbohydrate foods. It starts where the enamel is defective or has been removed, spreads through the dentine to the pulp-cavity, causing *acute pulpitis*. If the infection passes through the apical foramen, *periodontitis* occurs with discomfort and elevation of the tooth. The pulp usually dies and decomposes, with the formation of gas and pus which escapes under pressure through the apical foramen. If the pulp-chamber is not opened, the pulp removed, and the root-canal vented and treated, an *apical*, *alveolar*, or *periodontal abscess* forms, which: (1) Discharges through the alveolus and gum (*parulis*, or *gum-boil*), (2) the cheek (*sinus*), or (3) antrum (*sinusitis*); (4) strips off the periosteum; or (5) invades the inferior dental canal with necrosis of the jaw (*osteomyelitis*). A chronic swelling over the bony palate (*palatine abscess*) may follow the spread of pus between the bone and muco-periosteum from an upper incisor. This refills after evacuation, until the offending tooth is removed or properly treated. In all chronic abscesses or sinuses about the jaws, the possibility of a dead or infected tooth, a retained portion of root, or an impacted tooth should be considered. Many patients, treated for years for a suppurating sinus or antral disease, have promptly been cured by the extraction of a tooth or portion of retained root.

Treatment.—*Prophylaxis* includes: Care of the teeth, the prompt filling of cavities, the early removal of infected pulp; the disinfection, treatment, and careful complete filling of the pulp-chamber and root-canal. With the formation of an apical or periodontal abscess, the root-canal should be freely opened. If a sufficient vent cannot be obtained through the tooth, the abscess should be opened through the alveolus, and not permitted to burrow under the periosteum or to the skin of the face. In persistent cases, *apicoectomy* (removal of the apex

of the root of the tooth through an alveolar incision) or extraction of the tooth is necessary. Extraction during the very active stage of a streptococcic infection, particularly of the second and third molars, has repeatedly been followed by serious spreading infection, and even death. Particularly is this true where the dentist or surgeon has neglected to enforce absolute rest, and has used meddlesome local measures, such as curettage, incisions, or bone operations, when the temperature and pulse have risen after the extraction.

Secondary Complications.—Acute necrosis of the alveolar margin, cellulitis of the neck, cervical adenitis, septicemia.

Periostitis.—*Varieties:* (1) Acute. (2) Localized. (3) Diffuse. (4) Mercurial. (5) Phosphorous. (6) Arsenical. (7) Exanthematous. (8) Tuberculous. (9) Syphilitic. (10) Actinomycotic.

Acute periostitis and **osteomyelitis** usually involve the mandible, and may be localized or diffuse.

Etiology: (1) Difficult eruption of the deciduous or permanent teeth. (2) Traumatism in the extraction of teeth, or (3) contusion or fracture of jaw. (4) Infection from devitalized or carious teeth, or from alveolar abscess. (5) As a complication of the exanthematous fevers, typhoid, anemia, syphilis, tuberculosis, rickets, or exposure; or (6) as the result of the action of mercury, arsenic, or phosphorus. (7) Infection occurring through the mouth, nasal mucosa or sinuses, or the circulation. Syphilis is rarely responsible.

Varieties: (1) Simple non-purulent. (2) Purulent. (3) Periostitis ossificans (rare), characterized by soft, spongy, bony tissue that progressively develops without pain.

In mild cases or those treated early, resolution may occur, but usually periostitis proceeds to suppuration, sinus formation and necrosis, a part or the entire jaw gradually being loosened, and finally expelled in portions or in one large mass (*sequestrum*). New bone (*involucrum*) is formed from the periosteum and may, in time, partially surround the teeth, which have lost their old bony sockets and are merely attached to the soft tissues.

Prognosis.—An extensive osteomyelitis continues for from one to three years, before all of the necrotic bone has been expelled and the sinuses closed. From the prolonged suppuration, anemia and cachexia, amyloid changes in liver, spleen and kidneys, or secondary infection of the respiratory tract may occur and be fatal. Early and repeated operations are desirable to relieve tension, to secure adequate external exit for the pus, to remove dead bone, and for cosmetic reasons.

The mortality is 60 to 75 per cent.

Treatment.—1. *Incision* and *drainage* with the least operative trauma. The drainage is continued until the virulence of infection has subsided, dead bone separated, and new bone sufficient to maintain continuity of jaw formed (ninety or more days). 2. *Sequestrectomy* as soon as dead bone has loosened (about three months), without damaging the granulation tissue, periosteum, or new bone. If the bone is not found loose and "worm-eaten," operative removal is delayed three more months.

The teeth and roots should not be removed. Incisions are made *within* the mouth along the alveolar process or *without* along the lower surface of mandible.

Forming bone and granulations should not be damaged. Injections of methylene-blue solution into fistulous tracts give a valuable guide in operating.

To reduce the odor from fistula Condy's fluid or other mild antiseptic deodorant should be freely used as a mouth-wash and for injection.

Mercurial Periostitis.—The individual susceptibility to mercury varies greatly. *Salivation* may follow the administration of a few grains of calomel (10 to 20 cgm.) in a person with idiosyncrasy. Children between the ages of five and ten, and patients with myxedema and nephritis, are especially susceptible to mercurial poisoning.

The *first stage* is characterized by coppery metallic taste and salivation, or the constant flow of large quantities of saliva from the mouth; the *second stage* by swelling of the tongue, gums, and adjacent mucous membrane, beginning near the lower incisors. The teeth become tender, loose, and the gums dry, livid, burning, and bleeding. The *third stage* is characterized by fetid breath, ulceration, sloughing and necrosis of the gums, and falling out of the teeth.

Treatment.—(1) Mercurials should be discontinued. (2) Saline laxatives, iodids, and an excess of fluids are used to aid elimination. (3) Tincture of iodin, tincture of myrrh, and tincture of benzoin are used to stimulate the ulcerated or necrotic areas, and a potassium chlorate mouth-wash freely used.

Phosphorus periostitis or **osteomyelitis** (*phosphorus necrosis, phossy jaw*) affects workers in yellow phosphorus and contaminated red phosphorus used in the manufacture of matches and phosphorus bronze. On an average it occurs after five years, but may develop after three weeks' or thirty years' work in a match factory. The disease has now been largely eradicated by eliminating yellow phosphorus from factories. The phosphorus apparently reduces the general resistance to infection, permitting bacterial invasion of the bone. The process begins in the bone or periosteum, and often causes the loss of nearly the entire jaw which, in the course of two or three years, is expelled and replaced by a movable bony arch formed from the periosteum. Regeneration is much less perfect in the upper jaw, which is less frequently involved than the lower.

Symptoms.—(1) Slight intermittent ache from a decayed tooth or after an extraction, followed by (2) local swelling, loosening of teeth, putrid suppuration, only temporarily relieved by extractions and incisions. (3) The overlying skin becomes tense and swollen, and abscesses and fistulæ form from the necrotic bone. Aspiration of pus into the trachea may cause pulmonary disease, and from the upper jaw extension to the vomer, orbit, sphenoid, zygomatic bone, or brain occur. The mortality formerly was 50 per cent. Tuberculosis often is associated.

Treatment.—Prophylactic measures include cleanliness, ventilation, constant care of teeth, and avoidance of warm yellow phosphorus masses. When necrosis and suppuration occur and a supporting involucrum has formed, subperiosteal resection of the sequestrum should be done through the mouth or from beneath the jaw, and carried well into sound bony tissue. If the periosteum is spared, regeneration of the mandible occurs.

Arsenical periostitis and **necrosis** follow the devitalization of teeth by arsenic, and rarely extend beyond the alveolus on the approximal or buccal surface.

Etiology.—Arsenical necrosis results from (1) improper preparation or sealing

of a cavity in tooth containing arsenic; (2) the use of arsenic in a deciduous tooth with large apical foramen or absorbed root; and (3) in certain cervical cavities, drilled nearly to the pulp.

Treatment.—Arsenic in contact with the soft tissues should be neutralized by applying the hydrated oxid of iron; later sedative and stimulating applications are useful, such as those containing phenol, camphor, tincture of iodin, or benzoin.

Exanthematous necrosis occurs between the ages of three and eight, or during developmental periods of the teeth which are, of course, dermal appendages. In order of frequency, the necrosis follows scarlet fever, measles, smallpox. It may follow a mild, but be absent after a severe infection.

Symptoms include aching and soreness, swelling, redness, tenderness of gums, and fetid breath, occurring a few weeks after the attack of fever.

Tuberculous periostitis or **osteitis** chiefly involves the orbital margin of zygomatic and maxillary bones, with chronic abscess, fistula, sequestration, and ectropion formation. When the alveolar process is affected, there is swelling, ulceration, exposure of roots, falling of teeth, and necrosis of alveoli, with slight pain and much salivation. Pulmonary tuberculosis usually is associated.

Mandible.—The *primary form* is more malignant. The lower margin near the chin, the angle or the lower part of the ascending ramus are involved with a diffuse, hard, nearly painless, afebrile, swelling, and early trismus. Incisions and tooth-extractions are unavailing. Sinuses form with indolent granulations, denuded bone, and sequestra. The disease tends to recur despite removal or resection, with new fistula, lymphatic involvement of neck and back, invasion of glenoid, auditory meatus, and even the base of skull, and usually progresses to death after a course of several years. *Secondary type* originates from dental disease, beginning with (1) toothache, purulent periostitis, and general febrile disturbance, followed by (2) fistulæ and lymphadenomatous swelling. It is to be diagnosed from sarcoma, actinomycosis, and syphilis. Carcinoma of lower jaw is secondary to adjacent disease of the epithelial tissues, and occurs later in life. Tuberculosis runs a slower course than sarcoma, with lack of crackling and with lymphatic involvement and fistula. Actinomycosis is diagnosed by the character of pus and behavior of lymph-nodes, which generally remain unenlarged. Syphilis of the mandible is rare, and is associated with firm nodular swellings and other evidences of the disease.

Treatment.—Energetic surgical resection and closure after thermocautery or zinc-chlorid disinfection. Simple curettage is ineffective. If the mouth or conjunctiva are not invaded, zinc-chlorid sterilization, excision, and closure may be feasible. Treatment may be of little avail, from the poor general condition of the patient and the extent of the associated disease.

Syphilis rarely involves the mandible. A chancre may be inoculated upon the gums by a contaminated dental instrument. Localized gumma develops from the periosteum of the outer side of the jaw, usually near the angle and forms a smooth, hard, insensitive nodule that may resolve or develop exostosis. Liquefaction necrosis and discharge are uncommon. A diffuse gummatous infiltration may involve most of the bone. Paralysis of the inferior dental nerve occurs from the disease. These lesions may be mistaken for sarcoma. Above

the jaws, the preferred site for tertiary disease is the hard and soft palate, with the formation of gumma, osteitis, ulceration, and perforation of palate compli-

Fig. 647.—Hutchinson's teeth. The characteristic incisors are usually in the upper jaw.

cating mastication and speech. The inner framework of maxilla and base of skull may be involved, with the production of saddle-nose.

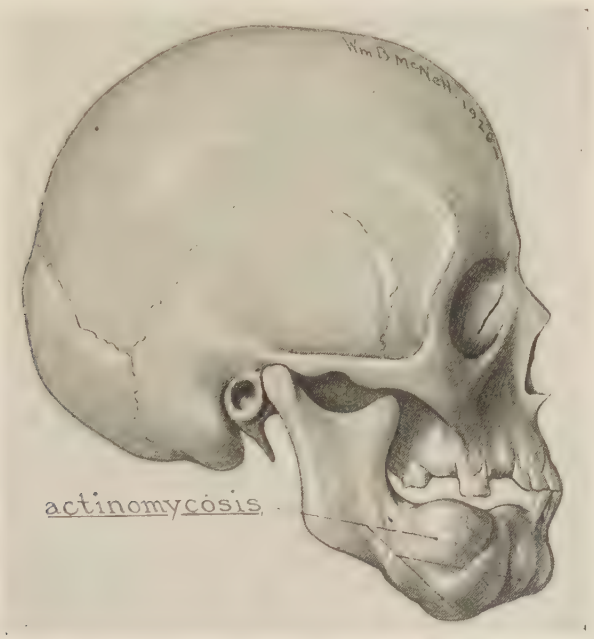


Fig. 648.—Actinomycosis of the mandible.

Treatment.—Three to 8 gm. of iodid should be given daily, with the intravenous use of arsenicals. Locally the parts should be kept clean and

protected from irritation. The insufflation of calomel and bismuth powder is useful. In perforation of the soft palate, a secondary plastic operation or the wearing of a plate or obdurator may be desirable. A plastic operation is rarely successful with a large opening.

Actinomycosis of the Face and Jaws.—*Infection* by the ray fungus usually starts from the mouth, and involves the teeth, cheeks, lower jaw, neck, and malar bones, the eyelids rarely being affected. It may spread from a carious tooth, a socket after an extraction, or the invaded parotid duct. Firm, painless, nodular swellings slowly develop, usually felt in the cheek in front of the masseter, and finally reach the skin, which becomes indurated and board-like. Sinuses form which discharge pus containing the characteristic grayish or yellowish granules.

In the maxilla the infection is more serious, with loosening of the teeth, abscess, fistulæ, bone necrosis, and involvement of the maxillary sinus, base of

Fig. 649.—Small fibrous epulis adjacent to an upper central incisor.

the skull, and adjacent soft parts. Gravitation abscesses may spread to the posterior mediastinum, and cause erosion of the vertebræ. In the early stages there may be no fever or pain, but later there is interference with mastication, with cachexia and emaciation.

Treatment consists of the intermittent use of large doses (6 gm. daily) of iodides, the application of the *x*-ray, the injection of the sinuses with a 2 per cent. solution of nitrate of silver, and the operative removal of as much of the diseased tissue as possible.

Alveolus epulis grows from the periosteum of the alveolus or periodontal membrane adjacent to a tooth, or in the gap between teeth, as a firm, red, smooth, rounded, sessile or pedunculated mass, which enlarges, becomes purplish in color, and from irritation may ulcerate or bleed. It recurs after removal, unless the attached portion of alveolus is also removed.

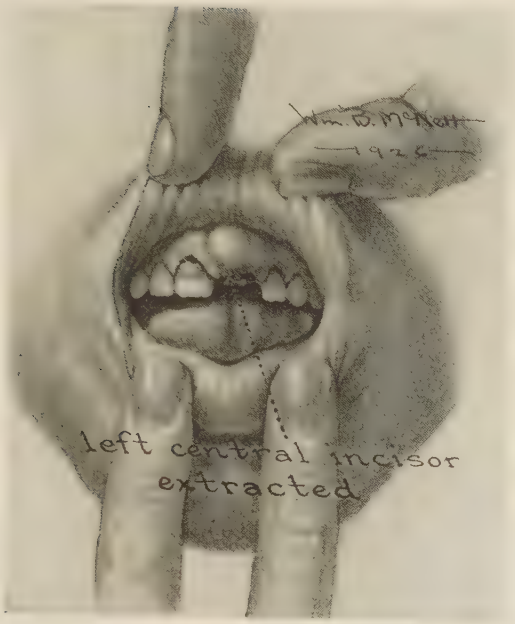


Fig. 650.—Method of removing an epulis: The adjacent irritating tooth has been removed.

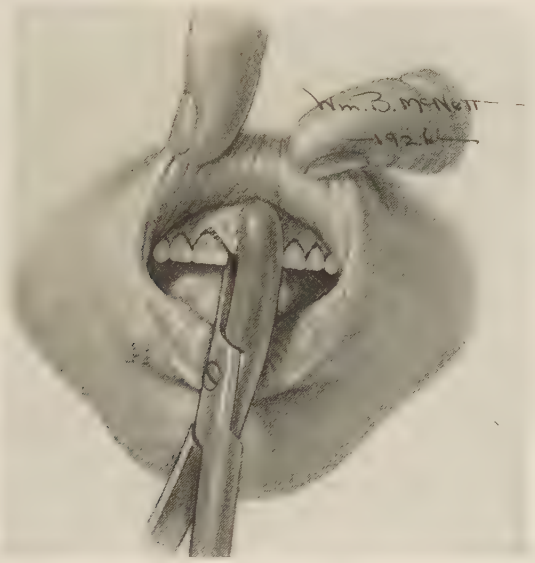


Fig. 651.—Method of removing an epulis: After extraction of the tooth the epulis with the underlying attached alveolus is removed by a single bite of a rongeur of appropriate size.

Epulis may be (1) *giant-cell* (the larger, more rapidly growing forms) or (2) *fibrous* in structure. It does not metastasize. It should be differentiated from a polypus, epithelioma, or angioma.

Treatment.—To remove sufficient of the alveolus, it usually is necessary to

extract the adjacent tooth. The epulis and adjacent alveolus should then be removed by a sharp rongeur under local anesthesia or nitrous oxid. Only a single bite of a rongeur of appropriate size is required.

Dentigerous Cysts.—Dental cysts are benign, painless, slowly growing, develop in the lower or upper jaw, and are usually filled with a glairy mucoid material. Eighty per cent. are *simple* or *radicular;* 20 per cent. are *follicular;* $\frac{1}{2}\frac{1}{6}$ of 1 per cent. are *multilocular* (Dorrance).

1. Radicular cyst (*simple dental cyst*) is a small unilocular cyst of inflammatory origin, arising about the apical foramen of a dead tooth, usually in persons between twenty and thirty years of age. The pulp dies, a granuloma develops, followed by a slowly developing cyst from the sheath of Hertwig, the epithelial rest-cells secreting a gelatinous fluid. If the process is rapid, an abscess is formed. The site is chiefly about the upper central incisors, cuspids, and molars, or the lower central incisors.

Diagnosis is based on a slowly developing mass, usually in the anterior part of the upper jaw, with protrusion from alveolus and adjacent buccal or palatine plate, or floor of nostril. Roentgenogram shows a defect in maxilla adjacent to the root of a devitalized tooth.

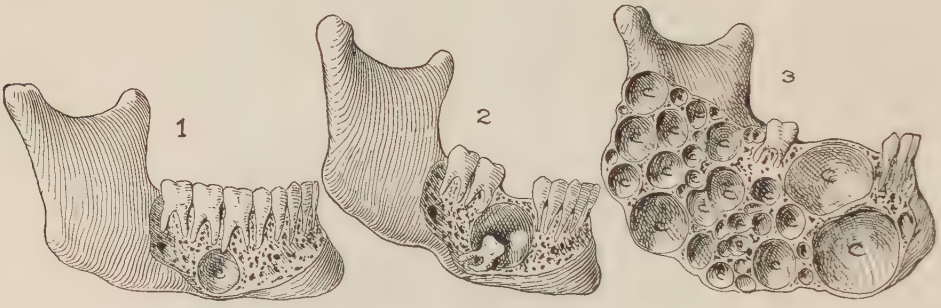


Fig. 652.—Cystic tumors of the mandible (semidiagrammatic): 1, Radicular cyst of the mandible, a simple inflammatory cyst arising about the apical foramen. 2, Follicular cyst developing from the follicle of an unerupted tooth. 3, Multilocular cystoma develops from the posterior part of the enamel-ridge with many cysts, the formation of new bone and great enlargement of the jaw.

2. **Follicular cyst** (*follicular odontoma*) develops from the follicle of an unerupted permanent or supernumerary tooth, the crown of which projects into the cyst. It occurs between the ages of twelve and twenty years, usually in the mandible, but also in the superior maxilla. The cyst slowly enlarges, and the thinned overlying bone may give egg-shell crackling on pressure. The roentgenogram visualizes the unerupted tooth in the wall of the cyst.

3. **Multilocular cyst** (*epithelial odontoma, proliferating follicular cystoma, fibrocystic disease of the jaw*) involves the ramus and posterior part of the body of the mandible in persons between twenty-five and thirty-five. It develops from the posterior part of the enamel-ridge with columns of epithelial cells, like an epithelioma, the formation of many cysts, and new bone, great enlargement and deformity of jaw, and at times malignant changes.

General Diagnosis.—*Broca's rule:* A new growth in the jaws that occurs after complete development of the teeth is not an odontoma. Simple dental

cysts are connected with the apex of a dead tooth, usually a superior cuspid. Follicular cysts often involve the lower jaw (usually where a tooth is missing), give egg-shell crackling and, by roentgenogram, show the crown of the tooth in the cyst wall. Multilocular cysts involve the posterior part of the lower jaw, with the formation of a large dense mass with multiple cysts, showing on the roentgenogram.

In all types the cysts are regular, rounded, painless, and free from inflammatory symptoms; and from them mucoid fluid may be withdrawn through a strong aspirating needle. Cysts of the maxilla may project on the buccal or palatine surface near the alveolus, or from the floor of the nostril or antrum.

Sarcoma grows more rapidly, more often causes pain, does not show a mucoid cyst, with a smooth epithelial lining covered by bone, and does not grow from the apex of a tooth or the enamel-sac.

Treatment. — For *small simple cysts:* (1) The extraction of the tooth, or (2) careful filling of the root-canals; with an apicoectomy, removal of the bony buccal wall and lining of the cyst, and suture of the alveolar mucous membrane. For *larger cysts* the buccal wall may be completely removed, so that the lined cyst becomes an accessory cavity of the mouth (*Partsch's method*); or, in the upper jaw, by removal of both buccal and nasal bony walls, as in a *Caldwell-Luc operation*, the cavity being drained by a packing brought out through the nose, the alveolar mucosa being closed by sutures. The drainage opening should not be made from the palatine side.

Fig. 653.—Multilocular dentigerous cyst of the jaw (Dr. M. Wohl).

Fig. 654.—Osteosarcoma of left side of mandible, rapid development following traumatism, apparent disappearance under radiation followed by rapid recurrence and death after second blow upon the jaw.

For *multilocular cysts* an extensive and often difficult removal of bone is desirable to resect and contour the mandible. If the section of mandible has not been destroyed and there is no evidence of malignant change, this is best

done by large motor-driven bone-burrs, although a chisel, gouge, or rongeur can be used.

Carcinoma of the Lower Jaw.—Varieties: 1. Infiltrating. 2. Papillary.

The first produces early metastasis. The papillary type of squamous cancer forms a bulky tumor in the mouth, with slow growth and late infiltration of periosteum and extension to cervical lymph-nodes.

Etiology.—An irritated and unclean mouth, acid saliva as occur with infections about the teeth, retained tooth roots, ill-fitting dentures, and excessive smoking favor the development of carcinoma.

Treatment.—(1) *Operation:* Resection of the jaw (Dupuytren, 1812) is followed by freedom from recurrence in 15 to 20 per cent. The average duration of life without operation after the patient first applies for treatment is ten months (Scudder). After complete excision the average duration of life is fifteen and one-half months. (2) *Radiation:* It is impossible to produce in bone or cartilage the reaction to radiation that occurs in soft tissues. The periosteum is resistant to both tumor invasion and radium necrosis. Bone is exactly opposite. Radiation sufficient to destroy cancer also destroys considerable bone and the secondary necrosis is very troublesome. The most efficient means of applying the major part of the dose is by interstitial implantation of filtered capillary tubes of radium emanation.

Tumors of Upper Jaw.—(1) *Tumors of the alveolus* and *teeth* have already been described. (2) *Tumors of the body of jaw* grow from the bone, periosteum, or mucous membrane of the antrum.

Benign Tumors.—*Fibromas* and *chondromas* are rare, grow externally from the periosteum or internally within the antrum, producing pressure, deformity, and absorption of bone and other tissue. *Osteoma eburnum* or *cancellatum* grows slowly within the antrum, or on the outer surface of the jaw.

Treatment.—Benign tumors of the jaw are to be excised as is required to relieve deformity or pressure symptoms.

Malignant Tumors.—*Sarcoma* may be periosteal or endosteal, osteogenic or non-osteogenic, growing from the outer surface of the jaw or into the antrum. Often they grow rapidly, producing great deformity and marked pressure-symptoms. *Carcinoma* arises as a columnar-celled growth from the mucous lining of the antrum.

Symptoms.—Pressure from within antrum with absorption and penetration of bony walls: (a) *Anterolateral*, with bulging of cheek, toothache (dental branches of fifth nerve). (b) *Superior*, with diplopia and proptosis from encroachment upon the orbit. (c) *Mesial*, with obstruction of nostril and epiphora. (d) *Inferior*, with depression and invasion of hard and soft palate. (e) *Posterior*, with invasion of sphenomaxillary fossa (neuralgic pains in the distribution of all branches of the second division of the fifth nerve).

The overlying bone may be thinned and give egg-shell crackling, later necrosis, ulceration, and severe hemorrhages occur. Transillumination and the *x*-ray show an opacity of the antrum.

From the posterior wall of the maxilla tumors invade the sphenomaxillary and pterygomaxillary fossæ, with swelling in the temporal region, posterior orbit

(*proptosis*), nasopharynx, and cranial cavity (through base of skull, and foramen rotundum and ovale).

Diagnosis.—*Carcinoma* originates in the gum or mucous membrane, usually in men after middle life, especially in the region of the molars and in an area of chronic irritation from a tooth or denture. A crateriform ulcer forms, and the bone is invaded, with induration, fixation, and severe pain. *Sarcoma* causes a larger, more rapidly growing, softer, and more vascular growth, which is less painful; it grows from periosteum or the central canal, and not from mucous membrane or epithelial glands.

Diagnosis should be made from tic douloureux, empyema of the antrum, and benign tumors. In case of doubt an exploratory biopsy is desirable.

Prognosis is bad. Recurrence after excision or destruction of carcinoma or sarcoma in the antrum is usual.

Treatment.—Excision of the upper jaw for sarcoma is not warranted by the results. Treatment by radium often is followed by the temporary disappearance of the tumor, and prolongation of life for two or three years. The improvement may be at the expense of a violent radiation neuritis.

Carcinoma may, in the early stage, be treated by excision of the upper jaw and the tributary lymphatics in the neck; with advanced carcinoma only palliative treatment should be used.

Excision of the upper jaw is best done under narco-local anesthesia, with preservation of the swallowing reflex.

Ferguson's incision is along the lower border of the orbit to the side of the nose, curving around the alæ nasi to divide the lip in the midline. The flap is turned outward, a central incisor extracted. The maxilla is divided from the opposite maxilla, the zygomatic bone, the nasal bone, the nasal process of the frontal bone, and the hard and soft palate by saw or heavy cutting forceps, and the partially liberated jaw grasped and removed by lion-jawed forceps. The floor of the orbit is usually removed, and extension of the growth into the frontal sinuses may be found. The internal maxillary artery is early controlled to prevent serious hemorrhage. The large cavity is packed with iodoform or bismuth gauze moistened with compound tincture of benzoin, and the external wound carefully closed. Later the defect in the palate and depression of the cheek may be corrected by a suitable dental plate and obturator.

CHAPTER XXXVIII

THE MOUTH, TONGUE, AND SALIVARY GLANDS

THE MOUTH

Gingivitis.—Inflammation of the gums varies in severity from slight redness, swelling, and tenderness, to greatly swollen, spongy, bleeding, even ulcerated or necrotic gums, with extreme fetor, and loose and elevated teeth that may fall out.

Etiology.—(1) *Mineral poisoning* as in *mercurial salivation*. Bismuth poisoning, as from the use of Beck's paste, is associated in the early stage with a blue line on the gums and, if more advanced, by gingivitis with ulceration. In lead-poisoning a blue line (*sulphid of lead*) on the gum-margins occurs where the gum-margins are in closest contact with decomposing food and tartar. (2) *Cachexia*, as in scurvy, advanced nephritis, cretinism, or exanthematous fevers.

Treatment should be (1) general, directed toward the cause, (2) eliminative, and (3) local. Calomel and other mercurials are interdicted. The *local treatment* should include the care of the teeth and mouth, the stimulation of ulcers or necrotic areas by tincture of iodin, myrrh, or benzoin; and the frequent use of *liquor antisepticus*, *liquor antisepticus alkalinus*, *Condy's fluid*, or potassium chlorate in the form of a mouth-wash. Under treatment loosened teeth usually regain a firm attachment.

Aphthous ulcers occur as very sensitive, single or multiple, small, rounded, superficial ulcers with a yellowish or greenish base and red injected borders, on inner surface of cheeks and lips and on the alveolar mucosa. *Relief and healing* follow the application of potassium chlorate or ammonium chlorate in crystal or paste, a 10 per cent. nitrate of silver solution, or touching the ulcer with phenol followed by alcohol.

Ulcers of the mouth frequently follow the use of coal-tar derivatives. In order of frequency (1) phenolphthalein, (2) luminal (phenobarbital), (3) acetphenetidin, or (4) antipyrin is responsible.

Vincent's Angina.—A superficial inflammatory disease of the mucous membrane of the mouth, pharynx, and fauces; occurring at all ages, and associated with Vincent's spirillum and fusiform bacilli and a false membrane, followed by well-defined, somewhat punched-out ulcers (*trench mouth*).

Symptoms.—Upon the mucous membrane of the gums, about the teeth, lips, cheeks, floor of the mouth, or tonsillar area and pharynx, a reddish, irregular, ill-defined area develops with a central whitish or grayish diphtheroid, adherent membrane. The membrané separates after a variable time, leaving small punched-out ulcers, especially behind the last molar and at the margins of the teeth. The systemic symptoms are slight, the lymphadenopathy moderate, the local inflammation rarely suppurative. The condition lasts from a few days to two weeks, or may become chronic.

Complications are rare and include severe ulceration, otitis media, and necrosis of the tonsils or the jaw. A similar condition is found in the genitals, but never on the skin.

The **diagnosis** is made by the symptoms, and by finding the spirillum and fusiform bacilli in the smears. Differential diagnosis is to be made from syphilis, diphtheria, tonsillitis, mercurial and bismuth stomatitis, pyorrhea alveolaris; erythema multiforme, in which there are bulla or ruptured bullæ; pellagra, in which a stomatitis or gingivitis frequently occurs; and acute leukemia, in which, due to leukemic infiltration, there may be marked hyperplasia of the gums overlapping and almost completely covering the teeth, at times associated with ulceration.

Treatment.—(1) The affected areas should be swabbed with *neosalvarsan powder*, which is specific, the application also being made to all gingival margins. (2) A second effective treatment is to cover the lesions and teeth with a paste of *sodium perborate*, the mouth being rinsed with warm water after five minutes. A gargle of the perborate should be used two or three times in a day.

Sprue (*tropical sprue*) occurs in the Philippines and is characterized by sore mouth, anemia, diarrhea, and loss of weight. It is due to *Monilia psilosis*, which grows on Sabouraud's medium with typical sugar reaction.

Pyorrhea alveolaris (*Riggs' disease*) is a marginal purulent gingivitis occurring about the necks of the teeth and adjacent alveolodental periosteum, with deposit of tartar and calcareous matter under the gum-margins, purulent discharge, recession of the gums, and finally loosening and loss of the teeth. The *Streptococcus viridans*, which is associated, often causes secondary arthritis, endo- or myocarditis, nephritis, anemia, gastro-intestinal disease, or other serious chronic metastatic infection. Pyorrhea is, therefore, one of the great sources of focal infection.

Treatment includes removal of tartar and calcareous deposit from the teeth and pockets by scaling and polishing, aseptization and stimulation of purulent pockets, the use of antiseptic mouth-washes, massage of the gums, and injections of appropriate vaccines. For severe forms extraction of the teeth is necessary.

Hyperplasia of the gums, with local irritation and ulceration, occurs during the eruption of the molar teeth. It is especially troublesome in the mentally defective. The redundant gum often overhangs an erupting wisdom-tooth and should be cut away. If the condition is very marked or tends to recur, the third molar may be extracted and, if necessary, a layer of the alveolus underlying the hyperplastic gum removed.

Polypus of the gums is a localized, usually pedunculated hyperplasia of the gums from the irritation of a tooth or denture, and should be excised and the base cauterized.

TONGUE

Congenital Anomalies.—Agenesis (Aglossia).—Complete or partial absence or atrophy of the tongue is very rare. Hemiatrophy occurs as an acquired condition, following injury or disease of the hypoglossal nerve.

Macroglossia occurs congenitally as a lymphangioma, with great dilatation of the lymph-spaces, or a fibromatosis of the nerves of the tongue. The en-

largement may be stationary, intermittent, or progressive, and is exacerbated by injury or infection.

Treatment.—The application of radium or, in rare cases, wedge-shaped resection may be used.

Bifid tongue, a split involving the tip, may require plastic closure for cosmetic reasons.

Tongue-tie.—A tongue with the tip so bound down by a short frenum or adjacent mucous folds, that it cannot be protruded beyond the incisors, is rare. The restraining bands should be superficially divided close to the tongue, and the organ liberated by blunt separation to avoid arterial injury.

Excessive length of the frenum and anterior attachments, permitting the tongue to occlude the pharynx and cause suffocation (*tongue-swallowing*) or to be introduced back of the soft palate, is not frequent, but justifies resection and suture of the frenum and anterior attachments of the tongue.

Wounds of the tongue, incised, lacerated or contused, may be complicated by hemorrhage, infiltration, infection with swelling, phlegmon, abscess, or osteomyelitis.

Etiology.—The tongue may be *bitten* during falls, convulsions from tetanus or epilepsy, or during narcosis. A *sting* by a bee or wasp may be followed by dangerous swelling, and even fatal suffocation. *Foreign bodies*, portions of pipe-stems, sticks, glass, bullets, and other missiles, may remain embedded in the tongue, forming a chronic swelling with more or less inflammatory reaction. In deep wounds the primary or secondary hemorrhage may be severe, and the control of secondary hemorrhage may be complicated by infection.

Treatment.—Hemorrhage is controlled locally by styptics, suture, or ligature. *Ligation* of the lingual artery through the submaxillary triangle may be necessary, if severe secondary hemorrhage occurs from an infected or sloughing wound. Catgut is advised for ligation, and horse-hair or silk for suture. Severe hemorrhage from the base of the tongue may be arrested by firm traction.

Dental ulcer—resulting from the irritation of a rough tooth, denture, or other source of chronic irritation—may become painful, indurated, and crateriform, suggesting an epithelioma. Ulceration of the tongue occurs during pertussis or advanced nephritis from the pressure of teeth and dentures.

The source of irritation should be removed, the ulcer asepticized by phenol followed by alcohol or by tincture of iodin, and the surface painted daily with compound tincture of benzoin. Carcinoma, syphilis, and tuberculosis should be differentiated by appropriate investigation.

Stomatitis ulcerosa occurs during the first and second dentition, in scurvy, mercurial stomatitis, aphthous stomatitis, in noma (*gangrenous stomatitis*), and from the chronic granulomatous infections, as tuberculosis, syphilis, and actinomycosis.

Treatment includes removal of the cause, with applications of iodin, phenol, copper sulphate, or silver nitrate to the ulcer, and the use of mouth-washes containing potassium chlorate, potassium permanganate, boric acid, myrrh, or benzoin.

Mucous cysts are small, thin-walled swellings of the mucous membranes,

and contain a mucoid fluid. They should be treated by removal of the lingual wall.

Ranula.—A painless, unilocular cyst of the floor of the mouth, 1 to 8 cm. in diameter, inconvenient from size or from pressure; with thin translucent wall, faint bluish color, and mucoid contents, resulting from obstruction of mucous glands, the anterior lingual (Blandin-Nuhn) glands, or, rarely, the smaller sublingual (Rivinus') ducts, the larger sublingual (Bartholin's) ducts, or the submaxillary (Wharton's) duct. The distention may occur during mastication.

Treatment.—Recurrence usually follows puncture or simple incision. (1) One or two setons of heavy silk may be introduced, (2) the lingual wall excised, (3) the lining cauterized by chromic or carbolic acid or zinc chlorate, or (4) the thin sac excised, leaving the wound open.

Leukoplakia buccalis (*psoriasis buccalis, leukokeratosis, tylosis linguæ*) is characterized by very chronic, smooth, milk-white patches that appear upon the tongue or, more rarely, cheeks, gums, or lips.

Etiology.—Occurs usually in middle-aged or elderly men, especially smokers. Many of the patients are syphilitic.

Symptoms.—Diffuse, bluish-white or milk-white, slightly raised patch, characterized by hyperplasia of the epithelium and loss of papillæ. Papillary overgrowth, with the formation of papilloma, ulceration, and carcinomatous change, occurs in 50 per cent.

Treatment.—The use of tobacco, alcoholics, and irritating foods should be avoided. An associated syphilitic disease should be treated. The tongue may be dried and painted with tincture of benzoin compound daily. The occasional application of chromic acid, copper sulphate, or nitrate of silver may be of some value. The guarded use of radium is often helpful.

Smoker's Patch.—A smooth, denuded red area that later becomes crusted or pearly gray from epithelial overgrowth. It occurs on the dorsum of the tongue near the midline, where the hot tobacco smoke first impinges.

Leukoma.—A diffuse, bluish-gray or whitish film of hyperplastic epithelium that may cover a large area of the tongue, gums, and cheeks, with a tendency to inflammation, desquamation, and superficial ulceration and ichthyosis, in which the papillæ become enormously hypertrophied, forming hard, wart-like, papillary areas.

Treatment for leukoma and smoker's patch is similar to that for leukoplakia.

Black hairy tongue (*black tongue, melanoglossia*) is characterized by elongation of the papillæ on the dorsum of the tongue anterior to the vallate papillæ. There are long, hair-like growths that are dark or black from the presence of bacteria. The condition may spontaneously disappear and require no treatment.

Marginate Glossitis.—Relatively smooth, slightly reddened areas, somewhat difficult to differentiate, appear along the margin of the tongue; associated with burning, stinging, and marked sensitiveness. The glossitis is to be treated by interdicting tobacco, alcoholics, and irritating foods. The areas may be lightly cauterized with chromic acid or nitrate of silver every five to seven days, dried, and painted daily with compound tincture of benzoin.

In obstinate forms of glossitis where the lesion becomes hard and indurated, ulcerated, or papillomatous, it should be excised, examined for epithelioma, or treated by radium.

Geographic tongue (*eczema, erythema, pityriasis of the tongue, wandering rash*) is characterized by very superficial desquamation of epithelium, the area spreading as the central parts heal, producing curious geographic outlines. It occurs in infants, children, and adults associated with slight symptoms, as itching. Often it is transient, but tends to relapse. Geographic tongue is not serious, and requires no special treatment apart from the use of mouth-washes.

Bednar's aphthæ consist of ulcers on the hard palate in children, due to injury from the use of an artificial nipple or by the finger.

Syphilis of the Tongue.—*Chancre* may develop upon the tongue, with much infiltration and secondary enlargement of the submaxillary glands. In

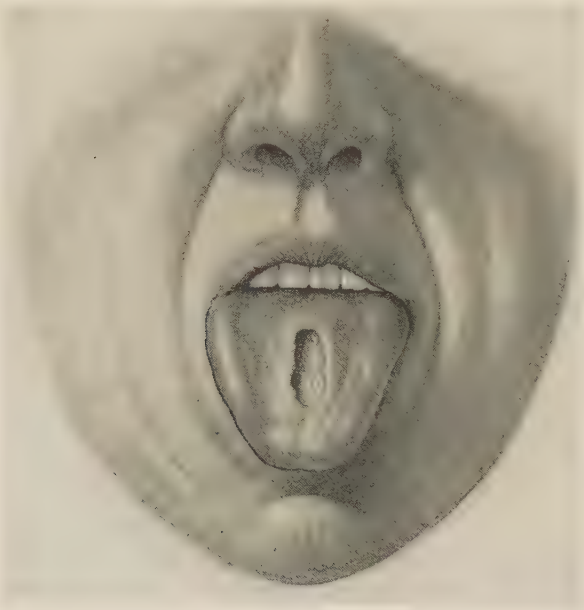


Fig. 655.—Ulcerated gumma of the dorsum of the tongue, the usual position.

the *secondary stage*, multiple, shallow, painful small ulcers, mucous patches, and condylomata (*Hutchinson's wart*) appear around the edges and on the dorsum of the tongue. In the *tertiary stage* (1) a chronic superficial glossitis, (2) a diffuse fibrous thickening of the tongue, or interstitial glossitis, the organ being large, hard, distorted by furrows and fissures, or (3) gumma with ulceration occur. Gummata develop near the midline of the dorsum, chiefly in men during middle life. They open and discharge, leaving a nearly painless ulcer with sharply cut, punched-out, thin overhanging edges, and a base formed by a tough grayish or yellowish slough like wet wash-leather. Fixation or enlargement of the regional lymph-glands may be absent, the lesion may last for many months, and an epithelioma finally may develop in the residual scar.

Actinomycosis.—Usually a single, bluish-red, isolated nodule, 1 to $1\frac{1}{2}$ cm.

in diameter, appears upon the tip or dorsum, with or without preceding evidence of injury by the teeth or otherwise. A secondary infection with abscess formation may occur in the nodule. If acute there is severe pain, throbbing, tenderness, and swelling.

The regional lymph-nodes only enlarge from complicating pyogenic infection.

The usual picture of nodular diffuse mass, with an indefinitely outlined induration, multiple sinuses, and abscess formation, is rare in the tongue.

Prognosis.—Free excision usually results in recovery.

Treatment.—Free excision with the internal use of iodin and potassium. Radium should be used for lesions resistant to other forms of treatment.

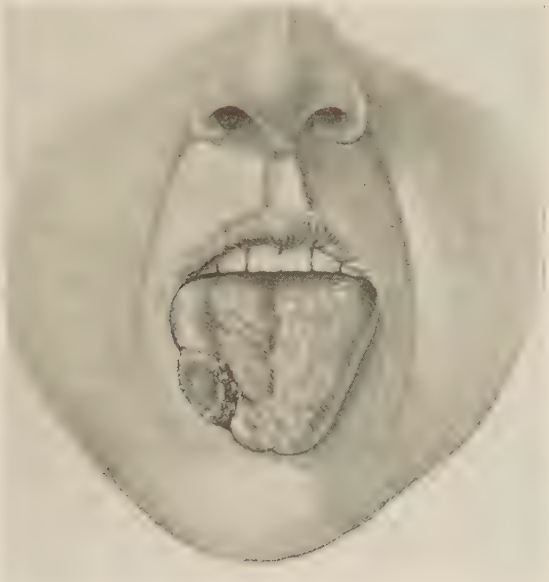


Fig. 656.—Epithelioma of the right margin of the tongue. The margin of the tongue is usually involved.

Dermoid cysts grow beneath the tongue in the floor of the mouth between the mylohyoid and hyoglossus as a sequestration dermoid, and reach the size of an egg or orange.

Treatment.—(1) *Enucleation* from beneath the jaw, with closure without drainage. (2) *Opening and evacuation* through the mouth by a median incision beneath the tongue, the sac being extracted, with temporary drainage or packing of the cavity.

Carcinoma of the Tongue.—Epithelioma of the tongue in about 85 per cent. of the cases affects men between forty-five and sixty-five years of age, and follows chronic irritation from carious teeth, a rough pipe, tobacco smoking, irritation of an ulcer, syphilitic scars, leukoplakia, or papilloma.

Symptoms.—As a rule, the anterior two-thirds and edge of the tongue are involved by (1) a *warty outgrowth* or (2) *crateriform ulcer* with hard everted margins, ragged foul base that bleeds on slight manipulation. *Later* the sub-

maxillary lymph-nodes enlarge, there is profuse fetid discharge and salivation, and the tongue becomes fixed from infiltration of the floor of the mouth, and cannot be protruded. The growth may spread to the fauces and tonsils, the internal organs being rarely involved.

Prognosis.—Death occurs in from one-half to two years from associated sepsis, pneumonia, cachexia, or hemorrhage. The submental or submaxillary glands are usually first involved from growths at the side or tip of the tongue, followed by the carotid lymph-nodes extending from the carotid bifurcation to the skull and sternum. Later the nodes on the side opposite the growth become infiltrated.

Treatment consists of the removal of the tongue and involved glands, except where there is extensive involvement of the fauces, larynx, jaw, or the carotid lymph-nodes. The operation is best conducted under local and narcotic anesthesia.

1. *Intrabuccal operation* (*Whitehead's operation*) is used for early growths where the tongue may readily be protruded, and when the floor of the mouth is not involved. The tongue is pulled from the mouth by traction thread or tenacula, the mucous membrane of the floor of the mouth divided, the lingual arteries exposed and ligated, and the tongue gradually enucleated from before backward.

2. *Lateral extrabuccal operation* (*Kocher's operation*) is used when the root of the tongue is involved, the jaws or fauces slightly involved, and when the tongue cannot be well protruded. An incision is made from the lobule of the ear to the great cornu of the hyoid bone, along the hyoid bone to the symphysis. The submaxillary glands are removed, the lingual or external carotid artery tied, the mouth entered through myelohyoid muscle, the tongue brought out into the neck, and excised back to the epiglottis and down to the hyoid bone, together with any diseased portions of fauces, tonsils, or mandible. Finally the incision is carefully closed in layers without drainage.

3. *Median extrabuccal operation* (*Syme's operation*) is used for disease of the anterior portion of the tongue with involvement of the floor of the mouth or symphysis. *Incision* from margin of the lower lip downward in the midline to the middle of the hyoid bone. The jaw is drilled on each side of the midline, divided by a Gigli saw, the halves of the bone separated, the tongue drawn out and forward and carefully excised, with ligation of the vessels as they are met. After amputation the halves of the mandible are wired together, and the external incision closed without drainage. In all cases a thread should be fixed in the stump of the tongue, which is pulled forward in case asphyxia threatens. The patient should constantly be watched during the first three days after operation. The stump and raw surfaces are painted with a varnish of iodoform or thymol iodid in compound tincture of benzoin or Whitehead's varnish.

A preliminary or postoperative tracheotomy may be necessary.

The operative mortality is 7 to 17 per cent., being greater with the extrabuccal operations. Recurrences after operation vary from 20 to 80 per cent., depending upon the type of carcinoma and extent of the disease at the time of the original operation.

Asphyxia from falling back of the stump, septic pneumonia, or secondary hemorrhage may follow the operation. Two or three weeks after the removal of the tongue the submaxillary and parotid lymph-nodes should be removed, if infiltrated, preferably by an extensive *en bloc* excision, including the sternomastoid and internal jugular vein.

Radium.—Advanced forms of carcinoma of the tongue may show marked improvement after the application or introduction of radium. The growth also may be removed by diathermy or electrocoagulation.

Palliative treatment may be required for pain, fetor, radium neuritis, and salivation—mouth-washes, application of tincture of benzoin compound, insufflation of thymol iodid. For the relief from pain, the application of orthoform, or the section or alcoholic injection of the lingual and inferior alveolar nerves (with or without the upper cervical nerves) is used.

Intracranial division of the glossopharyngeal nerve, combined with cervical rhizotomy, has been used by Fay for severe pain in the throat, and for dysphagia associated with inoperable carcinoma of the tongue and soft palate.

SALIVARY GLANDS

Anatomical Considerations.—The **parotid gland** weighs from 16 to 32 gm. ($\frac{1}{2}$ to 1 ounce), lies between the masseter, ramus and angle of the jaw, and between the zygoma, the sternocleidomastoideus, and posterior belly of the digastricus. The mesial surface is close to the internal carotid, internal jugular, and vagus, glossopharyngeal, accessory, and hypoglossal nerves. (1) The *pterygoid lobe* lies between the pterygoid muscles, (2) the *glenoid lobe* back of the glenoid cavity, and (3) the *carotid lobe* lies between the external and internal carotid arteries. The socia parotidis empties by a separate duct into the duct of Steno.

Within the parotid gland: (1) The external carotid artery divides into the superficial temporal, transverse facial, internal maxillary, and postauricular arteries; (2) the facial nerve breaks up into the pes anserinus; (3) the great auricular nerve joins the facial.

The *parotid duct* (duct of Steno or Stenson), 7 cm. long, runs a fingerbreadth below the zygoma, or on a line from the upper part of the lobule of the ear to the midpoint between the margin of the upper lip and the nose; it crosses the masseter, and passes obliquely through the buccinator, to empty opposite the second upper molar tooth.

The complete removal of the parotid is a difficult operation, necessitating resection of the facial nerve (facial paralysis) and the ligation of a number of arteries.

The **submaxillary gland** weighs about 8 gm. (2 drams), lies in the anterior part of the submaxillary triangle, and is grooved posteriorly and above by the external maxillary artery. The submaxillary duct (*duct of Wharton*), 5 cm. (2 inches) in length, passes over the lingual nerve, and empties through a papilla at the side of the frenum of the tongue.

The **sublingual gland,** weighing 2 gm. (0.5 dram), lies beneath the forepart of the tongue and mucous membrane of the floor of the mouth. The sublingual ducts (*ducts of Rivinus*) open with the *duct of Wharton* and the *duct of Bartholin;* lobules at the forepart of the sublingual gland, and the accessory sublingual gland empty by Walther's ducts on the floor of the mouth.

Removal of the submaxillary and sublingual glands produces little functional disturbance. Dryness of the mouth follows removal of the parotid gland.

Congenital anomalies of the salivary glands are rare. The excretory duct may be atresic, absent, transposed, or show abnormal orifices. Very rarely congenital fistulæ, opening above the sternum, are present. Enlarged, misplaced, or transposed salivary glands may be mistaken for tumors.

Traumatism.—Open or closed wounds of the *submaxillary* or *sublingual glands* usually are of little importance, the gland tending to heal promptly with, at times, a temporary fistula. The treatment of open wounds is by accurate coaptation with suture and pressure, the use of a liquid diet, and the interdiction of talking or chewing. Fistulous tracts should be treated by cauterization and pressure.

Subcutaneous rupture or **open division of the parotid duct** occurs from injury or operation, and is diagnosed by the infiltration of the tissues with saliva or by the escape of saliva from the open wound. In the wound the projecting ends of the duct may be observed.

Prognosis.—The duct may unite primarily, or leave an external or internal fistula. An internal fistula into the mouth is harmless, but an external salivary fistula from the parotid may be very troublesome. The divided duct should be united, if possible, by fine catgut, any external wound being carefully closed without drainage. If a secondary persistent salivary fistula occurs, it should be treated, as described below, by closing the external wound and producing a vent into the mouth.

Inflammation of the salivary duct (*sialodochitis*) usually is associated with inflammation of the salivary glands (*sialadenitis*).

Etiology.—(1) The *entrance of bacteria* into the duct from the mouth. (2) *Metastatic* infection of the gland, after abdominal operations, typhoid, pneumonia (3) The presence in the duct of stones or other *foreign bodies.* In glass-blowers, air may enter the duct which exudes in froth on pressure. In sialadenitis the orifice of the duct is red, injected, pouty, and fibrin or pus may be expressed followed by clear or turbid saliva. From chronic inflammation the duct dilates and thickens, and recurrent salivary colic may occur.

Treatment consists in removing any cause of infection in the mouth or pharynx, such as carious teeth, infected tonsils or adenoids. The use of mouth-washes, the gradual dilatation of the duct by sounds, the irrigation of the duct with a weak solution of nitrate of silver, permanganate of potash, or of boric acid solution and, in obstinate cases, the incision of the duct from within the mouth to obtain better drainage may be required. Foreign bodies should, of course, be promptly removed.

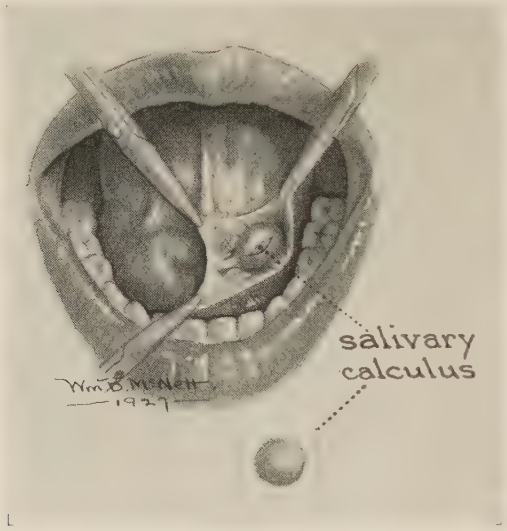


Fig. 657.—Exposure of salivary calculus in submaxillary duct.

Foreign bodies, such as cereal grains, splinters of wood, pieces of bone, seeds, bristles, hairs, and bits of feathers, are most frequently found in the submaxillary duct.

Symptoms may be slight, or there may be violent salivary colic, with an intermittent salivary tumor from the retained saliva. The orifice of the duct becomes red, swollen, and discharges pus; the corresponding salivary gland enlarges and, if the foreign body is not expelled, an abscess or fistula or secondary calculus may develop.

Diagnosis is made by inspection, sounding, palpation, the *x*-rays, and the history, or by operative exploration.

Treatment consists in the removal of the foreign body. It may be necessary to dilate or incise the orifice or part of the duct or, except with the parotid, even to remove the inflamed gland. The removal of the submaxillary or sublingual gland produces little disability.

Sialolithiasis (*salivary stones*) is a rather rare condition, characterized by attacks of salivary colic, and usually by a hard swelling, felt and sometimes seen in the floor of the mouth. The stones consist of phosphate or carbonate of lime, bacteria and other organic matter, may be single or multiple, and range in size from that of a grain of wheat to a bean or larger. They are chiefly found in men of middle age, but also occur in children; usually in the duct, but sometimes in the salivary gland. About 62 per cent. are found in the submaxillary duct, 20 per cent. in the parotid gland or duct, and 18 per cent. in the sublingual duct.

Etiology.—The stone originates from a foreign body, from bacteria, or from an inflammation of the duct or gland with chronic purulent or ulcerative catarrh, abscesses, fistula, or phlegmon.

Symptoms may be slight or absent, the stone first being noticed as it is accidentally felt in the floor of the mouth or is suddenly discharged. Often a chronic interstitial or a suppurative inflammation of the salivary gland is associated with *pyorrhea salivaris* and a tender mass in the floor of the mouth marking the site of the stone. Obstruction which may occur on mastication during or meals produces intermittent salivary colic, with slight or violent pain and enlargement of the gland.

Diagnosis is made by inspection, palpation, probing, incision, or the *x*-ray; if marked inflammation is present, the condition must be differentiated from alveolar periostitis, lymphangitis, Ludwig's angina, or a malignant tumor.

Treatment consists of the removal of the stone, usually through the mouth. This is best accomplished by a direct incision into the duct under local anesthesia. Occasionally, when the stone is small and near the orifice of the duct, dilatation and extraction are possible. If an external fistula or abscess of the gland is the seat of the stone, it may best be removed from without. If particles of the stone remain behind, recurrence follows. If the submaxillary or sublingual glands are seriously diseased and cause recurrence of the trouble, they should be extirpated. The parotid gland may be partially resected, with care to avoid injury to the facial nerve.

Salivary fistula occurs from the *duct* or the *gland;* being *external* or *internal.* Only the external is important. The *symptoms* are a free discharge of saliva from the opening (especially on eating), local irritation, and eczema of the skin. Anorexia and deficient nutrition may be associated.

Etiology.—The condition results from: (1) *Trauma;* (2) *abscess;* (3) *ulceration* and *necrosis,* as from noma, tuberculosis, or syphilis; or (4) *congenital defect.* The secretion from the fistula of a gland is much less than that from a duct.

Diagnosis is made from a lymph fistula by the character of the fluid, and the influence of food and mastication upon the flow.

Treatment.—1. *Glandular fistula* usually closes spontaneously. The tract may be: (a) Cauterized by silver nitrate, pure phenol, or by the galvanocautery; (b) treated by excision and suture, or plastic operation. If these measures fail, (c) a complete excision of the submaxillary or sublingual gland may be made. Excision of the parotid gland usually produces facial paralysis and is rarely to be considered for non-malignant conditions. (d) Arrest of parotid secretion follows division of the auriculotemporal nerve, and operative division of the nerve has proved useful in controlling inveterate parotid fistulæ. From

the upper part of the mandibular nerve the auriculotemporal nerve passes back under the external pterygoid muscle and may be reached after it passes between the sphenomandibular ligament and the neck of the mandible to enter the parotid gland. As the secretory fibers come from the petrosal ganglion of the glossopharyngeal nerve, operations on the gasserian ganglion do not stop parotid secretion.

2. *Duct fistula* of the parotid gland may occur from the (a) buccal, (b) masseteric, or (c) glandular portion of the duct, usually with a single, occasionally with multiple openings. Several hundred cubic centimeters of saliva may flow in twenty-four hours.

The permeability of the inner orifice of the duct is first determined by sounding, or by injecting a solution of methylene blue. If the peripheral portion of the duct is open, the external opening is to be treated by cauterization and pressure, or excision and suture; if impermeable, an opening should be established from the fistulous tract into the mouth, by means of a silk thread seton or small rubber tube, the external opening being closed. In certain cases a direct implantation of the central end of the duct into the mucous membrane of the mouth is feasible. In very obstinate cases, where other measures fail, salivary secretion may be obviated by ligating the central end of the duct, a procedure which is not often advised on account of the severe reaction resulting.

Acute Parotitis.—1. *Parotitis epidemica* (*mumps, specific parotitis*) is characterized by a self-limited, non-suppurative, bilateral infection and enlargement of the parotid glands, usually occurring in the young, and frequently complicated by an orchitis, oöphoritis, or mastitis that may be followed by secondary atrophy.

2. *Parotitis purulenta* (*parotid bubo, acute suppurative parotitis*) occurs: (a) after stomatitis, salivation, suppuration of adjacent lymph-nodes, and other infections in the mouth. (b) Complicating a general infection, as typhoid, smallpox, scarlet fever, pyemia. (c) Secondary to abdominal operations, usually developing five to seven days after an operation on the gall-bladder, appendix, intestine, or female genitals. The infection may be metastatic, or an ascending infection through the duct favored by the dryness and bacterial overgrowth in the mouth.

Symptoms.—Swelling, fever, tenderness, and pain increased by mastication, followed later by redness of the skin. Fluctuation may be difficult to detect, on account of the thick overlying fascia.

Complications.—Diffuse phlegmon, facial paralysis, hemorrhage, septicemia, meningitis, purulent mandibulotemporal arthritis.

Treatment.—*Prophylaxis* includes frequent cleansing and moistening of the mouth after abdominal operations and during general infections. When swelling occurs, hot moist compresses of 2 per cent. aluminum acetate, saturated magnesium sulphate solution, or a layer of yellow oxid-of-mercury ointment, covered by cotton, should be applied. When suppuration is evident, incision and drainage is made by Hilton's method under local anesthesia or nitrous oxid, and the yellow oxid ointment continued until healing occurs.

Mikulicz's Disease (1892).—A symmetric and usually progressive enlargement of the lacrimal and salivary glands, occurring in persons between

twenty and forty years of age. The parotid, the submaxillary, sublingual, lacrimal, palatine, Blandin-Nuhn glands, the labial and buccal glands, and spleen may gradually enlarge without pain or evidence of active inflammation. The affected glands show lymphadenoid deposit, with infiltration and atrophy of secreting tissue. Paroxysms with enlargement occur, lasting from a few hours to several weeks. The condition may become stationary, or recede after a febrile disease, or treatment. Dryness of the conjunctiva and mouth (*xerostomia*) may accompany the deformity and, at times, salivary lithiasis, and narrowing of the ducts.

Treatment.—Benefit may follow the use of iodin, arsenic, and the *x*-rays.

Chronic parotitis follows obstruction of ducts, salivation, foreign bodies in the gland or ducts, poisoning by mercury, lead, copper, iodids, opium, and in uremia. *Tuberculosis* is very rare. *Syphilis* is rare, and chiefly involves the parotid with gummatous deposit, necrosis, salivation, and difficulty in talking and eating. *Actinomycosis* rarely involves the parotid primarily.

Tumors.—Benign Tumors: *Fibroma* and *myxoma* as pure tumors are exceedingly rare. *Lipoma* originates in the interlobular connective tissue, and may be difficult or easy to enucleate. *Angiomas* are very rare, may grow rapidly, and can be destroyed by the hypodermic injection of 50 per cent. quinin and urea solution. *Lymphangioma* produces a prominent, compressible, or fluctuating mass that may be transparent and subject to acute inflammatory attacks. The treatment is by injection, as for an angioma, or by extirpation. *Mixed tumor* of the parotid may be embryonic or a teratoma. Tumors derived from the branchial arches consist of elements resembling chondroma, myxoma, osteoma, sarcoma, endothelioma, and carcinoma, often with cyst formation, and are the common growths of the parotid. They occur especially between the ages of twenty and forty, in males, on the left side, and may follow injury. The growth is irregularly nodular, hard, often with cystic areas, encapsulated, movable, painless, and not attached to the cheek. Only 11 per cent. show malignancy.

Treatment.—Intracapsular enucleation, and the application of iodin. If malignant—as indicated by pain, facial palsy, attachment to and invasion of adjacent tissue—*en bloc* extirpation of the parotid and adjacent lymph-nodes and contiguous tissues, with secondary radiation for recurrence, is advised.

Malignant Tumors: *Sarcoma* as a pure tumor is rare in the parotid. *Carcinoma* is rather rare in the parotid, occurring as: (1) A *scirrhous growth*, which is soft, rapidly growing, and very malignant. (2) *Encephaloid cancer*, which may cause death in a few months. McFarland has shown the relative infrequency of malignant disease in the parotid.

Treatment is radical excision or radiation.

CHAPTER XXXIX

THE PHARYNX, LARYNX, AND TRACHEA

PHARYNX

Acute pharyngitis follows: (1) Trauma; (2) scalds; (3) burns from hot liquids, or from caustics; (4) infection, as in exanthemata, rheumatism, septicemia.

Symptoms include pain, redness, swelling, mucous secretion, and dysphagia. If the edema spreads to the epiglottis, dyspnea or asphyxia may occur.

Treatment.—(1) Inhalation of steam vapor medicated by compound tincture of benzoin, tincture of myrrh, menthol, phenol. (2) Cold followed by hot compresses externally. (3) Tincture of aconite, salicylates, ammoniated tincture of guaiac, or tincture of iron internally. (4) Scarification or tracheotomy if asphyxia threatens.

Chronic pharyngitis follows irritation from smoking, alcoholism, or public speaking and may be: (1) *Atrophic*—the mucosa is thin, smooth, glazed, and crusted, or (2) *Follicular*—the mucosa is red and dotted by large lymphoid nodes.

Treatment.—Avoid the causal irritation. Application of 10 per cent. glycerol of tannin, or glycerol of iodin; use of astringent, antiseptic, or stimulating lozenges.

Stenosis results from burns, scalds, or syphilis. It is characterized by adhesions of the soft palate, stenosis of nasopharynx or constriction of inferior pharynx and of the opening to esophagus.

Treatment.—Dilatation by bougies, with or without plastic division and suture of cicatricial tissue. Gastrostomy if starvation threatens.

Tumors.—**Postpharyngeal polyp** is a firm, fibrous, pedunculated tumor, growing from the vault of the pharynx and occluding the choanæ, causing mouth-breathing and physical and mental retardation.

Treatment.—Removal by the cold or hot snare. If very vascular, necrosis and destruction may be obtained by repeated injections of 1 or 2 c.c. of a 30 per cent. solution of quinin and urea into the growth, using a hypodermic needle.

Malignant tumors are rarely primary, and usually involve the pharynx by contiguity. Epithelioma (except in the early stage) is not amenable to extirpation, but only to destruction by desiccation, cautery, or radium.

Hemorrhage from the pharynx occurs in pharyngitis. It may indicate a general hemorrhagic condition, and should be differentiated from hemoptysis and hematemesis.

Edema of the uvula occurs in chronic interstitial nephritis, and in marked anemia or cachexia.

Retropharyngeal Abscess (Postpharyngeal Abscess).—1. *Acute:* The

abscess develops from infection of lymph-glands in the space between the pharyngeal wall and prevertebral fascia. *Etiology:* Usually a staphylococcic infection occurring in children between six months and seven years of age, following the exanthemata, coryza, or dentition. In older children or adults a cold abscess may form from tuberculous caries of the cervical vertebræ. *Symptoms:* An acute febrile disorder, with chill, vomiting and convulsions, dysphagia and choking, noisy inspiratory dyspnea with retraction of intercostal spaces, regurgitation of food and saliva, short dry cough and, at times, loss of voice suggesting laryngitis. The head is tilted back, fixed, the mouth held open, and there is pain on moving the neck. The swelling may not be recognized on inspection, but on palpation through the mouth the soft, boggy, or fluctuating swelling of the posterior pharynx is found. The abscess occasionally spreads laterally, and is palpable at the sides of the neck. Edema of the epiglottis and its attendant phenomena, dysphagia and enlargement of the cervical lymph-nodes, are frequently associated.

2. *Secondary* and *subacute* retropharyngeal abscess may follow the lodgment of a fish-bone or other foreign body in the posterior pharyngeal wall, or the spread of a middle-ear infection along the eustachian tube.

3. *Chronic* retropharyngeal abscess of tuberculous nature follows cervical Pott's disease.

Prognosis.—The acute abscess is dangerous, from pressure, suffocation, edema of the larynx, or rupture and flooding of the bronchial tubes with pus. Early incision is most important to prevent death from suffocation.

Treatment of the *acute abscess* is an immediate free median incision made by guarded bistoury through the mouth, with the finger as a guide. No anesthetic is used and the child is inverted to prevent the inhalation of pus. Tracheotomy may be necessary. The *tuberculous abscess* should not be opened through the mouth for fear of a serious mixed infection, but may be aspirated or incised from behind the sternomastoid, the opening being closed, drainage avoided, and the operation being followed by support and fixation of the head and neck.

Tonsillitis.—Acute Follicular Tonsillitis: An acute bacterial infection of the faucial tonsils, usually due to the streptococcus. The tonsils are swollen, red, with an exudation in the crypts forming cheesy masses, often associated with enlargement of tributary lymph-nodes in the neck. It may be followed by endocarditis, pneumonia, or Ludwig's angina.

Treatment.—Local and general. Tonsillectomy after the acute symptoms have entirely subsided.

Peritonsillar abscess (*quinsy, suppuration of the peritonsillar tissues*) follows acute or chronic tonsillitis.

Symptoms.—Unilateral swelling of the glossopalatine arch and soft palate, with dysphagia, fever, and other constitutional symptoms. Difficulty in opening the mouth. Palpable fluctuation develops in two to five days.

Treatment.—Hot fomentations to the neck. Incision through the mouth with a guarded bistoury, through the soft palate, parallel with the glossopalatine arch, from above down and toward the uvula to avoid the vessels near the tonsil. Recovery rapidly follows evacuation of the pus, which, however, may be difficult to locate.

Chronic Tonsillitis (Hypertrophy or Hyperplasia of the Palatine Tonsils).—The tonsils may be *submerged*, exuding puriform cheesy material on pressure; or *protuberant*, projecting beyond pharyngeal pillars, and interfering with respiration. The latter are most common between the ages of five and ten years.

Symptoms.—Respiratory obstruction and mouth-breathing, recurrent septic infections, as acute tonsillitis, enlarged cervical glands, otitis media, peritonsillar abscess; susceptibility to diphtheria, rheumatism, and scarlet fever. The tonsils are a portal of entry for tuberculous infection.

Treatment.—Tonsillectomy; removal of the tonsil in its capsule: (1) By the Sluder instrument or its modification, or (2) the tonsil is grasped, liberated from the glosso- and pharyngo-palatine arches and the constrictor pharyngeus superior by appropriate separators, and removed by a cold wire snare. Bleeding is controlled by gauze pressure or, if necessary, by ligation or suture of the arches.

Tuberculosis of tonsils and **adenoids** is common, and should be treated by tonsillectomy and adenectomy.

Syphilis of the tonsil occurs as: (1) Primary chancre; (2) secondary syphilitic ulcers and mucous patches; (3) tertiary gummata, with deep ulceration, scarring, and deformity. These lesions are to be treated by active antisyphilitic measures (see page 165).

Tumors of the tonsils are usually malignant. *Sarcoma* occurs in the form of a very malignant lymphosarcoma (usually in the young), a mixed-cell sarcoma, or occasionally a relatively benign giant-cell sarcoma. *Epithelioma* usually begins on the fauces or tongue, spreading to the tonsil.

Symptoms.—A rapidly growing tumor without pain or inflammation. Epithelioma causes ulceration with enlargement of submaxillary and cervical lymph-nodes; dysphagia, asphyxia, and secondary hemorrhage which is at times fatal.

Treatment.—(1) Excision through the neck with the associated lymph-nodes. (2) Implantation of radium or radium seeds.

Adenoids.—Hyperplasia of the lymphoid tissue of the pharynx (*pharyngeal tonsil*) and occasionally of that at the base of the tongue (*lingual tonsil*) usually is associated with enlargement of the palatine tonsils.

The enlargement is greatest between the age of five and ten years, and is characterized by chronic nasal catarrh, mouth-breathing, adenoid facies, deficient hearing, nasal enunciation, mental dulness, tendency to respiratory infection, alteration of shape of the thorax, pigeon-breast and Harrison's groove, enlarged cervical lymphatics, headaches, fetor to breath.

Treatment.—Removal by Beckman or Gottstein's curet, or the high-frequency current.

LARYNX AND TRACHEA

Congenital anomalies are rare, and include:

A. **Congenital fissures** and **fistulæ,** which result from defective closure of the third or fourth branchial clefts or defective union of the third or fourth branchial arches. In the former the opening is unilateral, near the sternomastoid; in the latter, in the midline. Fissure of the epiglottis also occurs. Tracheal fistulæ are rare.

Symptoms.—A minute orifice in the skin of the neck over the larynx or trachea, with discharge of drops of mucopurulent fluid, or, on forced expiration, air-bubbles.

Treatment consists of cauterization of margins of sinus or plastic operation.

B. **Fissure, backward displacement,** or **kinking of the epiglottis** may occur with or without symptoms from the defective closure of the glottis.

C. **Congenital stenosis** or **atresia,** from hypoplasia or membranous partition or diaphragm in the larynx, occurs with occlusion of the glottis. The diaphragm usually is dense, and difficult to remove by knife or cautery.

Treatment consists of dilatation, division, laryngotomy, or tracheotomy.

D. **Absence** or **hypoplasia** of one or more of the **laryngeal cartilages.** A tracheotomy or plastic operation may be required.

Laryngocele (**Aërocele**) **or Tracheocele** (**Trachelocele, Tracheo=aëro=cele**).—Hernial protrusions of the mucous membrane of the larynx or trachea between the tracheal rings, or from a defect in the cartilage may be congenital, or acquired from dilatation of the anterior or lateral mucous glands. The size varies from that of a pea to that of a hen's egg. They are usually found in adult males, and are at times multiple and bilateral. Laryngoceles are normal in the gorilla and orang-outang.

Symptoms.—A compressible gas-filled tumor that enlarges on coughing or blowing. Usually there are no other symptoms; dyspnea and altered voice may be present, or suffocation from the sudden enlargement of the tumor may occur.

Treatment is by pressure or open resection.

Foreign bodies in air=passages occur chiefly in children under three, but are found at all ages. The substances inhaled include peanuts and other nuts, meat, bone, or gristle, glass eyes from toy animals, pins, coins, whistles, toys, beads, pills, teeth and artificial dentures, corks, dental or surgical broaches, burrs, detached swabs, applicators, other instruments or objects placed in the mouth, nose, or pharynx, or inhaled from vomitus. Bullets and other missiles may enter the air-passages through the pharynx, neck, or thorax.

Pathology.—Complete obstruction of the pharynx, larynx, or trachea is followed by apnea, cyanosis, and death from suffocation.

Obstruction of a bronchus causes *atelectasis* if air cannot pass the obstruction on inspiration; or *emphysema* of the lung or lobe supplied by the bronchus if air passes on inspiration, but cannot escape on expiration. The foreign body becomes lodged, or moves with the air-currents. In the trachea the foreign body may oscillate between the bifurcation and undersurface of the vocal folds in coughing. The foreign body usually enters the right bronchus, as the opening is larger and in more direct line with the trachea, and as the septum lies farther to the left. In four-fifths of the patients the obstruction is near the bifurcation.

Local Reaction.—1. *Bronchitis* and *Tracheitis:* The mucous membrane becomes red and swollen, with increased secretion, pus formation, and at times ulceration. The reaction is more marked from objects of vegetable origin, such as peanuts (*arachidic or vegetal bronchitis*), than from metallic or mineral substances. Later, abscess and necrosis of the cartilage occur, exuberant granulations form, and the foreign body becomes embedded or encapsulated. Secondary dilatation of the bronchus (*bronchiectasis*) may follow.

2. *Pulmonary Changes:* Atelectasis and induration of the lung, or emphysema, bronchopneumonia, and pulmonary abscess frequently result from foreign bodies. Extension of the inflammation to the pleura and the chest wall is less common.

Symptoms from obstruction by foreign body: (1) In *the larynx* there is alteration or loss of voice, anxiety, cyanosis, croupy cough, unconsciousness or suffocation. (2) In *the trachea* there are attacks of spasmodic cough, inspiratory dyspnea with diminished respiratory murmur over both lungs, retraction of intercostal spaces on inspiration, and weakened voice. (3) In *the bronchus* there is (a) unilateral dulness, absence of breath-sounds, or (b) emphysema over corresponding lung or lobe; localized, persistent, whirring rhoncus with fixed pain and thrill; (c) unilateral mucopurulent bronchitis, secondary abscess of the lung, bronchiectasis or pneumonia, and occasionally empyema. A marked rise in temperature may occur after twenty-four or forty-eight hours.

Chronic obstruction of the upper air-passages produces lateral caving in of the ribs, a prominent sternum, pigeon-breast with tension upon the diaphragm at its insertion, causing linear retraction of the ribs (*Harrison's groove*).

Diagnosis is made by the finger, laryngoscope, bronchoscope, or roentgenogram.

Dyspnea from foreign bodies within the larynx, trachea, or bronchi should be differentiated from that from *swelling or edema of the mucosa*, as in edema of the larynx, asthma, diphtheria, laryngismus stridulus, spasmodic croup, laryngeal crisis from tabes and from worms; also from *injury or disease of the walls* of the air-passages, as fracture of the larynx or trachea; and *chronic inflammation* of the larynx and trachea, as from tuberculosis, syphilis, chondritis, and abscess. Dyspnea from foreign bodies should also be differentiated from that from *neoplasm*, *tracheal collapse*, *cicatricial stricture* or *contracture; paralysis* of the recurrent nerve; *external pressure* from enlarged thyroid, thymus, lymphatic glands, neoplasm, aneurysm, pericardial exudate, dilatation of left auricle, *fracture*, *abscess*, or *neoplasm* of the clavicle, sternum, or vertebra, or from *cervical* or *mediastinal cysts*, abscess, or neoplasm.

Prognosis should be guarded. A foreign body producing few symptoms may cause death after hours, days, or years, from secondary swelling, dislodgment with obstruction, or septic complications.

Treatment.—For a suffocative attack following the aspiration of a foreign body, the pharynx should first be swept with the finger to make sure that it is free. The patient should be inverted, and placed in a head-dependent position during coughing. Inversion and succussion of the patient is occasionally successful. The impaction of a foreign body upon the larynx from below may cause sudden laryngeal spasm and obstruction, necessitating an immediate tracheotomy to save life. Laryngeal irritation may persist after expulsion or removal of the foreign body, or be simulated by hysteria.

Acute Asphyxia: The patient is cyanotic, unconscious, and dying of suffocation. *Treatment* is cricotomy for the adult, or a high tracheotomy for a child. With less urgent symptoms and better facilities, a low tracheotomy or intubation may be used. Where death from suffocation is not imminent, or where facilities are at hand, laryngoscopy, tracheoscopy, or bronchoscopy with removal

of the foreign body is the preferred treatment. In exceptional cases, removal through the posterior thoracic wall (a very dangerous procedure) is used. Appropriate treatment for secondary pulmonary abscess or empyema may be required.

Fig. 658.—The Rose position with hyperextension of the neck, used for operations upon the mouth, pharynx, nose, for esophagoscopy and tracheoscopy.

Laryngoscopy, Tracheoscopy, Bronchoscopy (Kirschlein, 1894; Killian; Jackson). —No general anesthetic is required. The sensibility and reflexes of the pharynx and larynx are reduced by spraying or swabbing with 4 per cent. cocain or 2 per cent. butyn solution.

Position.—The patient lies supine upon a table, the head extended beyond the table and supported by an assistant who holds the jaws apart by a "bite block" or mouth-gag, while the occiput is forced toward the shoulders and approximates the interscapular space, elevating the anterior part of the neck. With a Jackson electrically lighted laryngoscope the tongue and epiglottis are retracted and the larynx explored.

Tracheoscopy, Bronchoscopy.—A Jackson bronchoscope is passed through the laryngoscope into the larynx, and the laryngoscope removed. The bronchial tree is entered and explored under direct vision, the patient's head being so held and moved by an assistant as to facilitate passage into the bronchi. It is slightly lowered to enter the middle-lobe bronchus of the right side, raised to enter the posterior-branch bronchus, moved to the right to enter the left bronchus, and to the left to enter the right bronchus. Secretions are removed by aspiration or sponging; foreign bodies by suitable forceps, hooks, or other devices. Safety-pins may require closure or rotation before removal under the fluoroscope; straight pins, rotation or special manipulation for dislodgment. The operator is guided to the foreign body by purulent secretion and edema of the mucous membrane; but it is to be remembered that pus may overflow and be seen in a healthy bronchus. After twelve hours, foreign bodies may be covered by swollen mucosa, and be difficult to detect. In expert hands, the removal of a foreign body from the bronchus without anesthesia requires but two or three minutes.

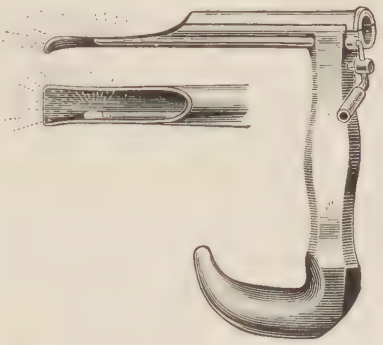


Fig. 659.—Jackson's laryngoscope and introducer for a bronchoscope.

Bronchoscopy should not be repeated more often than every seven to fourteen days, as a serious tracheitis and bronchitis follow the more frequent introduction of instruments.

Traumatic Injury. Concussion of the larynx may be followed by severe dyspnea, unconsciousness, and sudden death.

Treatment consists of artificial respiration or tracheotomy and restoration.

Contusion of the larynx gives symptoms resembling fracture of the larynx; ecchymosis, hematoma, and edema may be found on laryngoscopic examination.

Prognosis is favorable. Alterations of voice or aphonia may persist for weeks. Secondary perichondric abscess occasionally follows the injury.

Treatment is rest and antiphlogistic measures. Tracheotomy is necessary at times.

Fracture of the larynx is infrequent. The fracture is usually single, and (in order of frequency) the thyroid, cricoid, and arytenoid are involved. Multiple fractures of the hyoid and larynx and separation of the greater cornu are less frequent. The cricoid breaks on one or both sides, rarely in the median line. The muscles of the larynx and vocal cords may be involved, with secondary hemorrhage, edema, and obstruction.

Etiology.—Usually men between the ages of thirty and forty are the patients. The brittle calcified thyroid and cricoid cartilages of the aged favor fracture. *Direct violence*, producing lateral compression or anteroposterior flattening from a blow, kick, strangling or garroting, or *indirect violence* from weights falling upon the head causes the fracture.

Symptoms are reflex coughing, frothy blood-stained sputum, dysphonia, dysphagia, aphonia, stridor, cyanosis, suffocation, unconsciousness (frequent), and emphysema.

Diagnosis.—Laryngoscopy shows edema and hemorrhage; palpation, the displacement and mobility.

Prognosis.—The mortality is 33 per cent. Death may occur immediately, or after several hours or days, from suffocation, secondary edema, aspiration of blood, or emphysema. Only 2 cases of recovery are recorded after fracture of the cricoid. Union may be callous or fibrous. Secondary permanent constriction from deformity, fibrous contraction, or callus formation may necessitate the wearing of a tracheal tube.

Treatment for urgent dyspnea, emphysema, and comminuted fracture with considerable mobility is tracheotomy, which is the safest treatment in every case and should be done as soon as the diagnosis is made. With emphysema of the mediastinum or pleura, tracheotomy is useless. Suture or removal of a loose piece of cartilage may be desirable. Rest, external support, intralaryngeal medication and opium to reduce edema, relieve pain, and prevent cough are important in the after-treatment.

Fracture of the trachea is one-third as frequent as that of the larynx, and occurs from the same causes. It is often associated with injuries to the ribs and sternum, with penetrating wounds and injury to adjacent nerves. The separation is usually complete and transverse, at times with an intussusception from muscular action. The fracture is situated immediately below the larynx or at the region of the bifurcation, and one bronchus may be torn off. Longitudinal tears also occur with the cartilage pressed into the lumen.

Symptoms resemble fracture of the larynx, with pain above and behind the manubrium, gurgling or bubbling râles, dyspnea, and emphysema gradually extending to the surface. Mobility and crepitus may be obscured by the emphysema.

Prognosis is unfavorable. The mortality is 60 per cent., from suffocation, emphysema, or bronchopneumonia. Abscess and secondary sinuses may follow necrosis of cartilage.

Treatment.—Expectant, if dangerous symptoms are not present; tracheor-

rhaphy, if the area of fracture can be exposed for suture; tracheotomy and cannula tracheostomy for apnea.

Dislocation of the Larynx.—A rare condition in which the arytenoid is separated from the cricoid; may be associated with fracture. It gradually follows cicatricial contraction. Complete separation of the trachea from the larynx occurs from hanging.

Dislocation of Laryngeal Cartilages.—Complicated traumatic dislocation of arytenoid has not been reported. Dislocation or subluxation at the cricothyroid articulation, or habitual dislocation, indicated by pain, anxiety, and acute dyspnea, may be due to a relaxed condition of the capsule, or to muscular action, deep inspiration, sudden nodding of the head or vomiting.

Rupture of vessels, ecchymosis from muscular action or respiratory pressure, external hemorrhage, and rupture of the vocal cords often are associated. Coughing or straining at childbirth has been followed by fracture of the larynx or trachea. It is predisposed by tuberculosis.

Treatment.—Reduction may be accomplished by pressure and swallowing. Intubation or tracheotomy may be necessary to prevent death from suffocation.

Burns and **scalds** occur from the inhalation of steam, flame, or hot air; also from chemical caustics. Scalds from steam, hot or caustic fluids result in acute laryngitis, edema, exudate, secondary sloughing, and possibly cicatricial contraction. Severe bronchitis is usually associated.

Prognosis.—The mortality is about 20 to 50 per cent.

Symptoms.—Burns by *caustics* are less acute, but cause secondary edema of the epiglottis, redness, blisters, and severe excoriation. If by *steam*, the primary edema does not extend below the vocal folds, and a secondary membranous exudate forms with superficial necrosis.

Treatment consists of the antidote for the chemical caustic; demulcent antiseptic and anodyne sprays, drinks, and gargles; moist medicated inhalations; ice-bags or moist fomentations to the neck, and feeding by esophageal tube or rectum. Tracheotomy is used for obstructive symptoms, as cyanosis, unconsciousness, and apnea.

Occlusion, stricture, or **stenosis** of the larynx and trachea follow the lodgment of foreign bodies, traumatic injury; pressure from without as from abscess, tumors of the thymus, thyroid or lymphatics, aneurysm, cicatricial contraction; deflection and flattening of the tube as in scabbard trachea from goiter, paralysis of the vocal folds, injury or disease of the recurrent nerves, spasm of the vocal folds or intrinsic muscles; also edema, submucous hemorrhage, false membrane, and inflammatory adhesions. Complete obliteration is most common at the narrowest point, the glottis, from attempts at suicide by cut throat.

Symptoms vary from dyspnea on exertion to stridor and suffocation.

Treatment.—The cause should be relieved by the removal of foreign bodies, polyps, or tumors, and progressive dilatation by intubation. Tracheotomy or laryngectomy is used for intrinsic or extrinsic, chronic laryngeal, tracheal, or bronchial stenosis. *Inflammatory obstruction of the larynx* from diphtheria or other form of laryngitis is treated by the intubation of O'Dwyer. A laryngeal

tube of proper size is carried by a proper introducer into the larynx. The patient is bent slightly backward and firmly held, a mouth-gag introduced, the left forefinger carried behind the epiglottis which is held forward against the base of the tongue, and the tube guided along the finger into the larynx. The string attached to the tube is fastened to the ear or cheek by adhesive plaster. The tube may cause laryngitis and pressure necrosis, aspiration pneumonia, or peritracheal abscess. In certain cases a tracheostomy is necessary.

Open wounds of the **larynx** and **trachea** may be accidental, homicidal, or suicidal. They occur from without or within. Alarming hemorrhage may necessitate laryngotomy and tracheotomy and packing of the tube. Suicidal wounds have an oblique direction from below on the left side upward (in the right-handed), and are more superficial toward the right side. In the order of frequency, the thyrohyoid membrane, the thyroid cartilage, the cricohyoid membrane, and the trachea are incised. A self-inflicted free transverse separation, often through the esophagus to the vertebral column, occurs in the insane. The lower end of the trachea may be displaced or drop below the manubrium. The large vessels often escape, as the head is thrown back and the larynx is forward when the wound is made. Secondary hemorrhage may follow suturing of the skin without ligation of vessels.

Secondary emphysema and infection are frequent from gunshot wounds. Laceration from within may cause obstructive spasm of the larynx.

Symptoms are gaping wound, free hemorrhage, emphysema, hematoma, dysphagia, air-embolism; secondary spreading infection to mediastinum and elsewhere may occur.

Prognosis.—Longitudinal wounds are more favorable than transverse. The mortality of wounds of the larynx is 62 per cent.; and of the trachea 50 per cent. Complicated cases are usually fatal. Gunshot wounds of bronchi rarely recover. Stricture of the trachea, air-fistula, paralysis of the recurrent nerve, and bronchopneumonia may follow.

Treatment consists in the arrest of hemorrhage, provision for free respiration by removal of foreign bodies, and union of the trachea. Ligation, packing, and suture are best done under local anesthesia. The skin wound must not be closed without suturing the divided air-passages and esophagus and tying all blood-vessels. *Prophylactic tracheostomy* is used if there is dyspnea, tendency to secondary hemorrhage, or the presence of an unremoved foreign body.

Laryngitis may be acute or chronic, catarrhal, croupous, diphtheritic, ulcerative, tuberculous, or syphilitic. Suppurative or phlegmonous laryngitis may be submucous, mucous, or localized with the formation of an abscess. For the extreme pain of a chronic ulcerative laryngitis, insufflation of orthoform powder, acetate of morphia, bismuth, a menthol-oil spray, or the blocking of sensation by the injection of 60 per cent. alcohol into the superior laryngeal nerve may be tried.

Edematous Laryngitis.—Edema of the larynx, erroneously called "edema of the glottis" and formerly confused with croup, may be *obstructive* and follow injury, as wounds, fracture, or dislocation involving the cartilages; or burns and scalds from inhaled steam, flame, corrosive poisons, application of lactic acid or chromic acid; or foreign bodies impacted in the larynx; or adjacent infection or

inflammatory disease, such as diphtheria, tuberculosis, ulcerative laryngitis, acute glossitis, cellulitis of the neck, retropharyngeal abscess, or laryngeal chondritis. The edema also occurs from tumors and aneurysms of the neck and mediastinum with obstruction to the venous return; general anasarca from renal or cardiac disease, exanthemata or other general infections, or from the administration of certain drugs, especially iodids.

Pathology.—The swelling is chiefly of the glosso-epiglottic folds, the ary-epiglottic folds, the interarytenoid folds, and the epiglottis, with partial or complete occlusion.

Symptoms are local discomfort, hoarseness, cough, respiratory dyspnea, dysphagia, and pain increasing to apnea and death by suffocation, as in the cases of Washington and the Empress Josephine. The patient becomes apprehensive, agitated, flushed, livid, cyanotic and gasping, with exophthalmia and a strong, slow, and finally feeble rapid pulse.

Diagnosis is made with a laryngoscope.

Treatment consists of inhalations of warm medicated vapors containing menthol and tincture of benzoin, adrenalin spray, multiple punctures or scarifications of the exposed swollen mucosa, an ice-bag externally, and ice held in the mouth. Intubation and tracheotomy are used in extreme cases.

Abscess of the larynx may be intra-, peri , or retro-laryngeal. The abscess follows chondritis, phlegmonous and traumatic laryngitis, tuberculosis, syphilis, glanders, pyemia, smallpox, and other exanthematous diseases. Unless localized by injury the abscess occurs about the inferior surface of the epiglottis, the medial aspect of the arytenoids, and the ventricular folds.

Symptoms are those of a severe laryngitis, with local tenderness, dysphonia, dysphagia, dyspnea, hoarseness, stridor, and swelling shown by the laryngoscope, and perhaps a tender external swelling.

Treatment consists of internal or external incision and drainage, with tracheotomy when required for suffocation.

Perichondritis and **chondritis** follow trauma, chemical irritation and burns, syphilis, tuberculosis, cancer, typhoid, the exanthemata, and chronic laryngitis. It involves the cricoid and arytenoid cartilages most frequently, rarely the thyroid, with suppuration beneath the perichondrium, necrosis of the cartilage, and abscess formation. The abscess may rupture internally or externally, the pus and necrotic cartilage being spontaneously discharged, with secondary fistula, emphysema, or cicatricial contraction. Primary and metastatic inflammations usually affect the cricoid or the arytenoid, and a progressive ulcerative process may also involve the cartilages of the trachea.

Prognosis. Suffocation may occur from the swelling or the rupture of the abscess, collapse of the laryngeal wall, or secondary obliteration of lumen. The mortality is 40 per cent.

Treatment consists of evacuation of the abscess, and removal of necrotic cartilage. Loss of arytenoid cartilage does not usually cause much disability. The condition may necessitate rectal or esophageal feeding. Tracheotomy or laryngotomy is often required.

Aphonia occurs in acute laryngitis. It also occurs in chronic laryngitis, usually tuberculous and secondary to tuberculosis of the lungs, with infiltration

or ulceration of the vocal and ventricular folds, or distortion of arytenoids, preventing apposition of the vocal folds. Syphilis is a common cause, and may produce aphonia by affecting the cortex, the tenth cranial nerve, the recurrent nerve, or as a part of locomotor ataxia and paresis. Benign or malignant growths are usually papillomatous, and give a husky or whistling voice. Paralysis of intrinsic muscles expresses a focal neuritis, involvement of the pneumogastric or recurrent nerve (as from pericardial or pleural effusion), mediastinal mass, aneurysm of the aorta, thyroid disease, or enlarged glands of the neck.

Aphonia also follows infection involving the larynx in the course of typhoid, diphtheria, or the exanthematous fevers; embolism or infarction; operative or other form of trauma with fracture or dislocation of the larynx. Functional, neurotic, or hysterical aphonia is common and often relieved by acute mental or physical shock, especially by the sudden application of a strong static spark to the larynx while the patient is trying to say "oh."

Bilateral abductor paralysis occurs from thyroid enlargement, injury during operation for goiter, secondary edema or cicatricial constriction after thyroidectomy.

Symptoms are increasing inspiratory edema—the laryngoscope shows approximation of the vocal folds which is increased by expiration.

Treatment is tracheostomy.

Tuberculous laryngitis usually is secondary to pulmonary tuberculosis, and involves chiefly the posterior wall of the larynx about the arytenoids, vocal folds and epiglottis, with swelling of the epiglottic folds and bands and the under surface of the epiglottis. It begins posteriorly at the extremities of the aryepiglottidean folds, and on the interarytenoid folds, spreading forward. The mucous membrane is at first thickened and infiltrated, tuberculous nodules develop, followed by broad, shallow, worm-eaten ulcers covered by grayish exudate. The ulcers spread to and destroy the epiglottis, causing perichondritis, necrosis of cartilages, thickening of the vocal cords and, less often, a backward spread into the pharynx or stenosis of the larynx.

Diagnosis.—Carcinoma begins as a papilloma which ulcerates and infiltrates.

Prognosis.—It was formerly regarded as necessarily fatal. Not so now.

Early *symptoms* are huskiness, irritation followed by hoarseness, aphonia, cough, and dysphagia, which may be agonizing when there is ulceration of the epiglottis and pharynx.

Treatment.—The application of lactic acid, insufflations of thymol iodid or iodoform, and tracheotomy in the severe or obstructive types.

Syphilitic Laryngitis.—*Secondary lesions*, mucous patches, and condylomas develop with evidence of acute laryngitis, hoarseness, and irritation. Granulomas, extensive ulceration and, at times, destruction of cartilage with stenosis or occlusion occur as a more chronic manifestation of the secondary lesions. In the third stage gummatous formation and ulceration of the epiglottis are common.

Diagnosis.—Carcinoma is unilateral and begins as a papillary growth on the vocal and ventricular folds.

Treatment consists of antisyphilitic treatment, and insufflation of iodoform, bismuth, or calomel. Iodids should be used cautiously for fear of secondary

edema. A spray of menthol, olive oil, or Churchill's inhalant (potassium iodid in acetone, glycerin, and water) is used. Cauterization of ulcers with 50 per cent. lactic acid, and excision of the ulcerated epiglottis may relieve dysphagia, although the laryngeal condition may rapidly progress. The patient should be fed in *Wolfenden's position*, the head hanging over the side of the bed as liquid food is sucked through a tube.

Syphilis with stenosis is treated by dilatation by Schrötter's bougie.

Tumors of the larynx are usually intrinsic, two-thirds being single papillomata involving the anterior part of the vocal cords. They occur chiefly in males, in children, or even infants, and at times undergo later malignant degeneration.

Symptoms, which vary with the size and location, are uncertainty as to voice, alteration in timbre, diphonia (double voice), hoarseness, dyspnea, aphonia, and dysphagia. Dysphagia is rare unless the pharyngeal aspect of the larynx is involved. Cough and pain occur in the later stages.

Diagnosis.—Laryngoscope or finger-tip. Papillomata or fibromata are usually pedunculated, angiomata dark red and located upon the vocal folds. Cysts occur in the ventricles or epiglottis, and enchondromata on the posterior portion of the larynx, especially on the arytenoids.

Treatment consists of intralaryngeal cauterization, excision, snaring, crushing, or avulsion. Thyrotomy or thyrolaryngotomy may be necessary to give sufficient exposure. With division of the cricoid below and the hyoid above, union is better if a tracheal tube is inserted.

Extrinsic carcinoma of the larynx rapidly spreads and involves the extensive supraglottic lymphatic zone, which drains the epiglottis, the aryepiglottic folds, the ventricular folds or false vocal cords, and is, therefore, followed by early infection of the tissues of the neck.

Intrinsic carcinoma of the larynx involves the subglottic zone where the lymphatics are small and sparse, through which invasion of the adjacent tissues of the neck occurs late. *Carcinoma* often develops from a benign tumor and gives the symptoms of the benign tumor together with pain, emaciation, and, in the later stages, lymphatic involvement and laryngeal obstruction.

Treatment.—Partial or complete laryngectomy is largely restricted to the early stages of intrinsic malignant disease. Intralaryngeal operations for carcinoma usually are insufficient. In the early stage partial or complete laryngectomy eliminates the disease in 25 per cent. of the cases.

For extrinsic malignant disease in the early stages the tumor and adjacent tissues may be excised by a subhyoid pharyngotomy. The prognosis is unfavorable. Palliative treatment is used for advanced cases, and includes astringents and sedatives containing orthoform, anesthesin, or other sedative. Tracheostomy may be necessary to relieve obstructive symptoms.

Tumors of the trachea include fibromata, papillomata, osteomata, lipomata, enchondromata, adenomata, sarcomata, and carcinomata. Tumors are one hundred times more common in the larnyx. One-third of the tracheal tumors are malignant, 30 per cent. of the malignant tumors being sarcomata. Intratracheal thyroids may encircle the tube and involve the lower part of the larynx. The tumors usually arise from the membranes rather

than cartilage, are more common in the upper part of the trachea, are often associated with tumors in the larynx or elsewhere, and are more frequent in adult males. Benign tumors are usually pedunculated and malignant tumors sessile.

Symptoms are slowly developing inspiratory and expiratory dyspnea, audible stridor, flexion of the head without change in the quality of the voice.

Diagnosis is made by the tracheoscope.

Treatment is intratracheal excision or destruction, tracheotomy, or resection of the trachea. Complete operative excision is favored by the sparcity of lymphatics and the tendency for primary carcinoma to remain localized in the trachea.

OPERATIONS UPON THE AIR-PASSAGES

Cricotomy.—Intercricothyrotomy is the quickest, simplest, and safest method of introducing a tracheal tube by incision. In young children the space may not admit a sufficiently large tube. The patient is placed in a supine position, the neck elevated by cushion or sand-bag, the head extended, the larynx steadied by the thumb and finger, and a 4 cm. transverse incision made to the conus elasticus (cricothyroid) membrane, which is divided transversely through the mucosa, the cartilages spread apart by forceps or blunt scissors, and a laryngotomy cannula or tracheal tube introduced. The operation is used in laryngeal and pharyngeal obstruction, foreign bodies in the larynx or trachea, and as a preliminary to extensive operations upon the pharynx, mouth, and jaws. Local anesthesia is effective or an anesthetic may be given through the cannula.

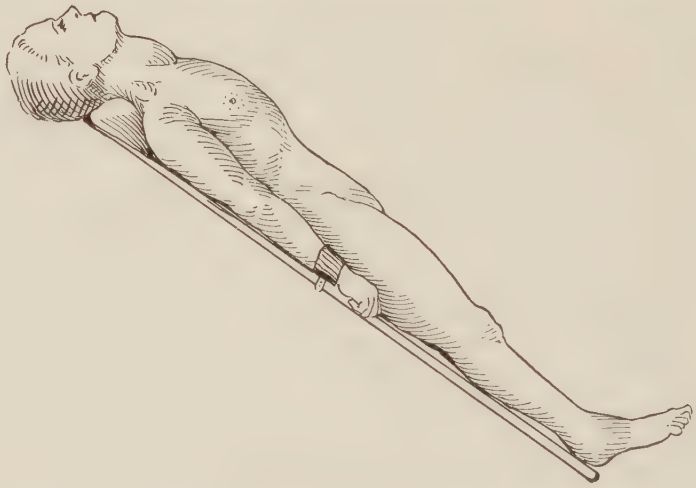


Fig. 660.—Elevation of the neck and extension of the head used for operations upon the thyroid, trachea, and larynx.

Laryngotomy (Thyrotomy).—The patient is supine, with the head extended, and the neck elevated and supported. (1) A vertical median incision is made from the lower border of the hyoid bone to the lower border of the cricoid cartilage, dividing the skin and cervical fascia, and separating the sternohyoid muscles. (2) The middle cricothyroid ligament and the thyroid cartilage are accurately divided in the midline by knife, scissors, fine saw, or thin bone-forceps, carefully avoiding the vocal folds. (3) The lateral halves of the thyroid cartilage are retracted, exposing the interior of the larynx contents.

The operation may be preceded by low tracheotomy, with the insertion of a Trendelenburg or Hahn cannula.

Indications: Removal of large impacted foreign bodies, of necrotic cartilage, of cancer or other neoplasm of the vocal folds or interior of the larynx, and also as the first step of a partial or complete laryngectomy.

Tracheotomy.—This is performed without anesthetic as a life-saving emergency operation upon the floor or bed with a penknife or scissors, the tracheal opening being maintained by a bit of rubber hose, the retraction of bent hairpins, or other makeshift. If acute asphyxia is absent, a local or general anesthetic may be used.

Indications: (1) Acute asphyxia from upper respiratory obstruction. (2) As an emergency method for producing artificial respiration, and for the removal of foreign bodies. (3) As a preliminary step in operations upon the upper air-passages, to prevent aspiration of blood or wound-fluids into the lungs. (4) In asphyxia and paralysis following division of both of the hypoglossal or recurrent nerves.

High or superficial tracheotomy is done above the isthmus of the thyroid gland with the patient supine, the head extended, and the neck raised and supported. A midline vertical incision is made from the middle of the lower edge of the thyroid cartilage downward for about 3 or 4 cm. The deep fascia is divided in midline, exposing the upper rings of the trachea. The thyroid isthmus lies over the third and fourth tracheal rings, and is displaced downward or divided if there is insufficient room. The trachea is fixed by a sharp hook inserted lateral to the median line, and the trachea opened in the midline by a knife introduced from below upward. The edges of the tracheal wound are separated by hooks or an opened hemostatic forceps, and the tracheotomy tube is introduced, around which a strip of iodoform or plain gauze may be packed to prevent the aspiration of wound secretions. Engorged veins collapse as soon as asphyxia is overcome. In operations upon the trachea and larynx, it is often desirable to instil a 1 per cent. cocain or butyn solution to overcome the reflexes from the mucosa.

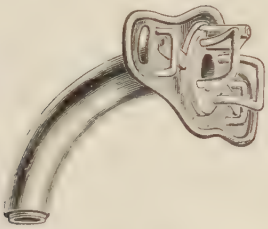


Fig. 661.—Tracheotomy tube. The inner tube is removable for cleaning.

Fig. 662.—Jackson's tracheotomy tube.

Low Tracheotomy. The position is that for the high operation. A median incision is made from the level of the cricoid cartilage downward for 4 or 5 cm., the cervical fascia is divided, and the veins separated or divided between ligatures or forceps. The isthmus of the thyroid may be retracted upward. The trachea is fixed by a sharp hook, the three rings divided from below upward, and a tracheotomy tube introduced. Low tracheotomy is not suitable for children, on account of the depth of the trachea, the shortness of the neck, and the encroachment of the thymus gland on the operative field. If obstruction from collapse of the trachea, pressure or other cause exists below the opening, a rubber gum-elastic, or flexible metal cannula (*König's cannula* or *lobster-tailed cannula*) may be introduced. To prevent leakage of fluid alongside the cannula, an inflatable rubber collar (*Trendelenburg's cannula*), or a layer of compressed sponge about the cannula (*Hahn's cannula*) is used. The cannula is retained by a tape passed around the neck. The inner tube should frequently be removed and cleansed, and inspissated secretions removed from the outer tube by a sterile feather or by minute sponges of gauze or cotton wet with boric acid *firmly* fastened, to prevent dislodgment, to an applicator or forceps. Only the surgeon should remove the outer tube during the early days, or before the opening has become well developed. To moisten the inhaled air, a fluff of moist aseptic gauze should be kept over the opening.

Preliminary tracheotomy (used before operations upon the upper air-passages) may be *preliminary*, performed two or three weeks before the major operation, or *immediate*, performed at the time of the other operation.

Laryngectomy may be partial or complete:

Partial Laryngectomy.—A median laryngotomy is first done, giving access to the interior of the larynx, and the affected half or section of the larynx is then excised.

Complete laryngectomy is performed through a median incision from the hyoid bone to or below the isthmus of the thyroid. If necessary, transverse incisions are made at one or both ends of the vertical incision. The upper end of the trachea is isolated, divided, and fastened to the skin at the lower angle of the wound or, better, to the edges of a separate lower button-hole incision. A tracheotomy tube may be introduced temporarily. The larynx is carefully separated from the esophagus, and the adjacent soft tissues, the epiglottis and aryepiglottic folds removed or saved, depending on the extent of the disease. If saved, it is occasionally possible to anastomose the upper end of the trachea with the divided end of the upper larynx, restoring the continuity of the air-passages. If removed, the opening in the pharynx should carefully be closed, and a permanent tracheal opening through the skin of the neck formed.

For the first two or three days the patient is nourished by rectum, or by an esophageal tube passed through the mouth or nose. He is encouraged to be out of bed after the second or third day. By carrying a tube containing a vibrating reed (*artificial larynx*) from the tracheal opening, through the nose, to the pharynx, audible speech in monotone is possible.

Pharyngotomy.—1. **Subhyoid.**—The patient is supine with the head extended, and the shoulders and neck elevated upon a cushion. (1) A transverse cutaneous incision is made, 5 or more centimeters in length, following the lower border of the hyoid bone. (2) Division of platysma myoides, omohyoideus, sternohyoideus, and thyrohyoideus on a line ½ to 1 cm. below the hyoid bone. (3) Division of hyothyroid membrane along the posterior surface of the hyoid. (4) The mucosa of the pharynx is divided avoiding the epiglottis, and traction sutures are inserted in the epiglottis.

Indications: Removal of tumors of the pharynx and epiglottis. A preliminary tracheotomy may be desirable. The wound is closed in layers, with a small drain or with a large pack, depending upon the extent of the excision.

2. **Transhyoid.**—A median cutaneous incision is made from a point one fingerbreadth above the hyoid to the thyroid notch, dividing the skin and subcutaneous tissue and separating the mylohyoideus. The hyoid bone is exposed in the midline, and divided by scissors or forceps. The two halves of the hyoid are retracted, and the pharynx is opened from above downward, incision being guided by a finger in the mouth. At the completion of the operation the wound is closed in layers with a small drain. Suture of the hyoid bone is unnecessary.

3. **Suprahyoid,** for access to tumors at the base of the tongue or on the epiglottis, is done by a transverse incision along a line ½ cm. above and parallel with the upper border of the hyoid, through the skin and platysma, retracting the submaxillary gland and insertions of digastricus, and dividing transversely the mylohyoideus, geniohyoideus, and hyoglossus. The pharynx is opened, giving access to the epiglottis, soft palate, tonsils, pharynx, and base of the tongue.

Bronchotomy.—Opening the bronchus through the thoracic wall rarely is indicated.

For a **right bronchotomy** a lateroventral position is used with the right arm hanging over the edge of the operating-table. A rectangular flap, hinged laterally, is formed internal to the scapula over the fifth, sixth, seventh, and eighth ribs, which are divided just external to the transverse process and as far laterally as possible. The flap is cautiously raised and reflected outward, hinging on the periosteum, intercostal muscles, and skin. The pleura and lung are pushed laterad, exposing the azygos vein and the esophagus and vagus nerve lying on the bodies of the vertebræ. In the concavity of the arch of the azygos vein the rings of the bronchus are palpated, and the bronchus fixed by a sharp hook and incised. The depth is about 7 cm. from the surface of the ribs. A tube may be introduced into the bronchus, surrounded by gauze packing.

Left Bronchotomy.—A left lateroventral position is used with the left arm hanging over the edge of the table, the osteoplastic flap is turned laterad, the parietal pleura separated, the arch of the aorta located on the side of the spine, and the pleura separated under the arch of the aorta for about 5 cm., exposing the left pneumogastric nerve. The lung covered by pleura is retracted laterally, and the bronchial cartilages located in the depths of the wound and incised.

CHAPTER XL

THE NECK

Congenital Anomalies.—**Cervical auricles,** skin tabs, fleshy projections containing cartilage (*accessory auricles*); accessory external ears (*polyotia*) develop from the second branchial arch, and are found over the sternocleidomastoideus, not united to any of the deep structures. The cartilage is cellular and has a surrounding perichondrium. The outgrowths cause no symptoms except deformity.

Treatment.—Excision and skin closure.

Teratomas.—A few tumors of the neck containing rudiments of another embryo have been reported. The growth is lateral or anterior, of irregular surface, a consistency varying in different parts, and is covered by normal unattached skin. It is present at birth, tends to grow, may move with deglutition, and produce dyspnea or dysphagia from pressure.

Treatment.—Excision, which may be difficult and dangerous on account of the deep attachments of the growth.

Fig. 663.—Congenital cystic hygroma of the neck.

Thyroglossal cyst, thyroglossal fistula, thyroglossal sinus (*median sinus of the neck*) develop from the remains of the thyroglossal duct, which extends from the foramen cæcum of the base of the tongue to the isthmus of the thyroid. The external opening, when present, usually is above the hyoid bone, the upper part of the tract is lined by squamous epithelium, the lower part by columnar or ciliated epithelium, with lymphoid tissue and mucous glands in the walls. The sinus usually develops in young men with a small median opening, secretes a small amount of turbid mucus, and the skin shows some irritation or crusting about the orifice. The depth of the tract may be shown by a roentgenogram, after injecting bismuth paste or iodid solution through the opening. Rarely is a complete fistula present.

Treatment.—Injection of caustics as phenol or zinc chlorid solution is usually followed by recurrence, and should only be made after determining the location and course of the sinus. Operative excision, after injecting methylene-blue as an indicator, is preferred, but may be difficult, the sinus passing alongside or through the hyoid bone.

Lateral sinus or fistula of the neck, formerly called *branchial fistula*, usually originates from the remains of the entodermal diverticulum (*thymus duct*), which arises from the pharyngeal part of the third branchial pouch and extends down-

ward to form the thymus gland. The internal opening is situated on the lateral wall of the pharynx, in the region of the posterior palatine arch close to the tonsil. The fistula passes above the hypoglossal nerve, and runs downward and laterally between the carotid and along the medial border of the sternocleidomastoideus. The external opening is situated a short distance above the sternoclavicular joint. As the lower part of the thymus canal most often persists, an incomplete external sinus is the usual form. It is lined by ciliated columnar epithelium. It is to be noted that the median cervical sinus is concerned with the development of the thyroid gland, the lateral cervical sinus with the development of the thymus.

Treatment.—Cauterization or excision.

Cervical Rib.—In the embryo, rudimentary elements of ribs occur in the cervical, lumbar, and sacral regions. In mammals, these embryonic rudiments ultimately fuse with and help to form the transverse processes of their respective

Fig. 664.—Bilateral cervical rib. (Roentgenogram by Dr. G. C. Bird.)

vertebræ. In reptiles and fishes, many or all of these elements proceed to the formation of true ribs. In man, accessory ribs occasionally develop in the lumbar and cervical regions; the former are usually short, are attached merely to the transverse process, have no head or articulating process connected with the body of the vertebræ, and are without clinical importance.

Cervical ribs are represented by the anterior portions of the transverse processes of the cervical vertebræ. When a distinct rib is formed, it may show a head, neck, and tubercle properly articulating with the seventh or, more rarely, the sixth cervical vertebra. The rib (1) scarcely extends beyond the transverse process, or (2) passes forward a varying distance, with a free end, or (3) reaches the first thoracic rib, to which it has an osseous, cartilaginous, or

fibrous attachment. Rarely it joins the manubrium through the intervention of the costal cartilage. Cervical ribs are bilateral in two-thirds of the reported cases, and are three times as frequent in women as in men. A so-called bicipital rib results from the fusion of the anterior part of the cervical with first thoracic rib. Very rarely more than one cervical rib is present upon the same side of the neck. The intercostal space formed contains intercostal muscles, and is in close association with the pleura. The scalenus anterior muscle is attached near the termination of the accessory rib, and the scalenus medius at is times inserted on both the cervical and the first true rib.

Centers of ossification appear in the cartilaginous tips of the transverse processes of the vertebræ at puberty, the process being completed about the age of twenty-five.

Symptoms result from mechanical displacement of the subclavian artery and brachial plexus, and usually develop at the time of adolescence or completion of ossification in the rib, but may occur at any time between the ages of thirteen and sixty, and be precipitated by trauma. (a) In the majority of cases no symptoms are produced. (b) Vascular symptoms: The elevation of the subclavian artery, as it winds around the anomalous rib, may produce a pulsating fulness in the neck that is mistaken for aneurysm. Circulatory weakness is shown by muscular wasting of the hand, with pallor, susceptibility to cold, lowered temperature, and occasionally by terminal gangrene of the fingers. The symptoms often improve on elevation of the arm, during warm weather, or from massage. The radial and ulnar pulse may be diminished or absent. Venous obstruction and edema do not occur. (c) Nerve disturbances are usually referred to the hand, are of the lower brachial-plexus type, and associated with paresthesia, numbness, tingling, neuralgic pains, diminution of electric excitability, and decreased motor power. The parts supplied by the sixth, seventh, eighth cervical and first thoracic nerves are chiefly involved, with atrophy or weakness of the intrinsic muscles of the hand and the flexor muscles along the postaxial border of the forearm. The symptoms are aggravated by a more posterior origin of the brachial plexus (*a postfixed plexus*). In the hand, the abductor pollicis brevis and opponens pollicis are chiefly affected. Vascular changes may be due to the irritation of the sympathetic fibers. Symptoms may appear suddenly after traction upon the arm or violent depression of the shoulder. To obtain relief the patient may develop a spinal curvature.

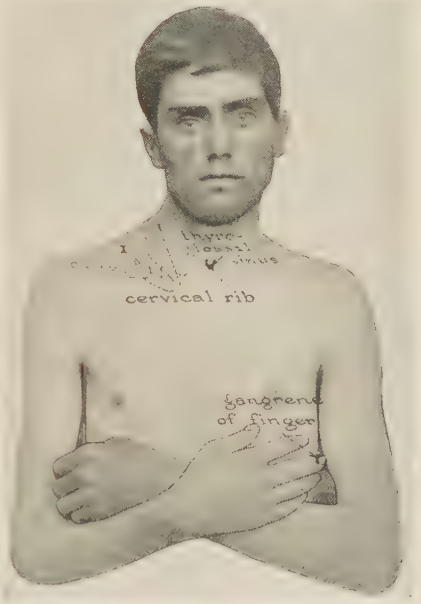


Fig. 665.—Ischemia of right hand and terminal gangrene of the middle finger from the presence of a cervical rib. Median thyroglossal sinus of neck. Rapid healing of finger after excision of the rib. Scoliosis.

Diagnosis.—Unilateral or bilateral prominence of the neck, Roentgen-ray study.

Treatment.—(1) Mechanical treatment, change of occupation, development of the trapezius and levator anguli scapulæ muscles to remove the strain from the lower brachial nerve-roots, and either elevation or depression of the shoulder or the arm, may give a degree of relief. (2) Excision of the rib (preferably with its periosteum to prevent re-formation) through a transverse or oblique supraclavicular incision is preferable. Care should be taken to avoid the brachial plexus, subclavian vessels, the accessory nerve, and the pleura. As a rule, marked improvement or complete recovery follows the costectomy. Relief of pressure by division of the scalenus medius has been suggested by Adson (1927).

Torticollis (Wry-neck, Caput Obstipum).—The neck is inclined toward the affected side, the face rotated to the opposite side, the chin pointing to the unaffected shoulder, with a primary curve of the cervical and a secondary curve of the thoracic spine. The sternocleidomastoideus and, at times, the trapezius, deep cervical muscles, and cervical fascia are contracted on the affected side. When persistent, there is atrophy of the face and facial bones on the affected side and secondary vertebral changes from the spinal curvature. Torticollis may be acute, acquired, chronic, congenital, irregular, spastic, reflex, paralytic, ocular, or psychic. Eight per cent. occur in the first ten years of life.

Etiology.—(1) *Congenital torticollis* results from prenatal contracture, a prenatal myositis, or a cervical hematoma occurring during or before birth. (2) *Dermatogenic torticollis*, from contracture of the skin of the neck, is the result of scars due to a burn, ulcer, or plastic operation. (3) *Myogenic torticollis:* A transient muscular contraction occurs from rheumatism, cold, or an acute myositis. A chronic form results from infections, as in scarlet fever, typhoid, or syphilis. A chronic fibrous myositis may cause a permanent contracture. (4) *Reflex torticollis* is due: (a) to enlargement of the cervical lymph-nodes, a not uncommon and transient form, which may be the first symptom of a tuberculous cervical lymphadenitis in childhood; (b) deep-seated inflammation, suppuration in the neck; (c) tumors of the tonsils, pharynx, neck, or brain. (5) *Neurogenic torticollis* results chiefly from pressure or irritation of the accessory nerve, as in: (a) Neuritis, meningitis, or tumor; (b) paralysis of the accessorius rarely follows vertebral disease, as Pott's disease or syphilis; (c) paralytic torticollis also occurs from poliomyelitis and diphtheria. (6) *Ocular torticollis* may occur from a high-grade astigmatism. (7) *Spasmodic torticollis* is characterized by marked muscular spasm. It occurs chiefly in the neurotic, and is obstinate and very difficult to relieve.

Symptoms.—*Simple Torticollis:* The head is merely displaced toward the affected side. In the *complex form* there is rotation of the head toward the affected side; or the head is displaced toward the healthy side, with a cervical scoliosis toward the healthy side, and a compensatory thoracic scoliosis toward the opposite side. On the affected side the eye is lower, the face shortened. The condition tends to increase during the growing period.

Diagnosis.—Pain, tenderness, and pain on movement suggest a deep inflammation or abscess of the neck, a rheumatic inflammation or caries of the

spine. True torticollis is painless. Cervical opisthotonos in a basilar meningitis may be mistaken for torticollis. A compensatory torticollis with a backward tilting of the spine occurs in rickets.

Tuberculosis of the cervical spine frequently simulates torticollis. The pain, cervical deformity, and Roentgen findings differentiate. Occasionally, secondary wry-neck occurs in arthritis deformans and in poliomyelitis.

Prognosis.—Favorable in the acute and simple forms, unfavorable in the chronic, neurogenic, and spasmodic type.

Treatment consists in relieving the cause. Massage and support or retention are used for the milder types. Marked and permanent contracture of the sternomastoid is treated: (1) By *tenotomy*, myotomy, or myectomy (with excision of the affected muscle); (2) by *stretching*, freezing with ethyl chlorid, or dividing the exposed accessory nerve, or injecting it with alcohol or a 5 per cent. solution of phenol; (3) *division* of the upper three cervical nerves when the trapezius, semispinalis capitus (complexus), and related muscles are involved. Any associated scoliosis should be corrected, and prevented from becoming permanent.

Intradural resection of the upper cervical motor-roots has been used by Cushing. The dermatogenic form is to be overcome by plastic operation or skin-grafting.

Spasmodic torticollis is allied to tics, and is of nervous origin; the prognosis is poor, often hopeless. *Treatment:* Every source of reflex irritation should be removed. Operative treatment is usually unsuccessful. The best results seem to be obtained from development, by gymnastic methods, of the muscles antagonizing those in spasm.

Cut-throat is suicidal or, less frequently, homicidal or accidental. A suicidal incision is from left to right and from below upward in the right-handed, the first part of the wound being the deeper. As the patient usually throws the head back and protrudes the larynx and trachea, the air-passages and even the esophagus may be divided without opening the carotid sheath. Hemorrhage is seldom immediately fatal, unless from asphyxia due to entrance of blood into the trachea. The wound gaps widely from the divided platysma.

Results. 1. *Immediate:* (a) Air-embolism; (b) asphyxia from obstruction, or from blood entering trachea; (c) exsanguination; (d) emphysema.

2. *Secondary:* (a) Wound infection; (b) cellulitis; (c) mediastinitis; (d) edema of larynx; (e) tracheitis; (f) inhalation pneumonia; (g) secondary hemorrhage.

3. *Remote:* (a) Tracheal, laryngeal, or esophageal fistula; (b) laryngeal or tracheal stenosis; (c) aphonia.

Wounds above the hyoid bone may open the mouth, divide the lingual and external maxillary vessels, enter the root of the tongue, and be followed by asphyxia from obstruction of larynx, due to the falling back of the epiglottis and base of the tongue. Through the hyothyroid membrane the pharynx may be opened.

Phonation and deglutition are hampered by the division of the depressor muscles of hyoid. The lingual, facial, and superior thyroid vessels and hypoglossal nerve may be injured.

At the level of larynx the vocal folds or thyroid lobe may be incised. *Below*

the larynx, the thyroid gland and its vessels, the recurrent nerves, and great vessels of the neck may be divided.

Homicidal wounds vary in depth, position, and extent, but often are deep and may even enter the spinal canal.

Treatment.—(1) Arrest of hemorrhage, ligation of all divided vessels. (2) Asepticization of wound. (3) Suture of wound in esophagus or air-passage (tracheotomy in certain cases). Closure of wounds through cartilage may be difficult. (4) Closure of skin and divided muscles, with provisional drainage.

Gunshot wounds produce wide-spread, destructive lesions in the neck. In a case in which a rifle grenade exploded close to a patient, a part of trachea, larynx, and adjacent portions of vertebral bodies were carried away. The trachea and gullet retracted behind the sternum. However, the patient recovered, with aphonia, a tracheal fistula, but no esophageal fistula.

Fracture of hyoid bone (rare) occurs by direct or indirect violence; as a rule, with displacement of the fragments.

Symptoms.—Violent local pain, increased by movement; swelling, dysphagia (*dysphagia valsalviana*), dyspnea, dysphonia, cough, possibly bleeding from the mouth.

Diagnosis by bimanual examination with one finger in the mouth.

Treatment.—Replacement by pressure; fixation by immobilization of head and neck with stiff collar and extension. Tracheotomy and the use of a stomach-tube may be required. Later, the removal of one horn of the bone is at times necessary, from non-union and secondary pressure-symptoms.

Acute periostitis of hyoid occurs with suppuration, abscess formation, and necrosis. Very rarely syphilitic nodes develop.

Tumors of hyoid bone are exceedingly rare. The growth is usually a chondroma, which may be cystic and produce serious pressure-symptoms with hoarseness, dysphonia, dysphagia. The treatment is excision.

Injury of thoracic duct occurs from stab, incised, or gunshot wounds, or operation. Loss of the serous or milky chyle is followed by malnutrition, wasting.

Treatment.—Suture, ligation, clamping, packing. The collateral lymph-circulation is efficient. Spontaneous closure is common after packing.

Nerve Injuries of Neck.—From operation or accidental injury the brachial plexus, accessory, recurrent, cervical sympathetic, hypoglossal, or the vagus nerves may be damaged in the neck.

Symptoms follow compression, tension, torsion, or division of nerves during operation; secondary edema or inflammation involving the nerve-trunks; or pressure by new connective tissue, aneurysm, or other new-growths. From irritation of the accessory nerve, torticollis; of the sympathetic in the neck, miosis and flushing and excessive perspiration of the face occur.

Compression or division of the seventh nerve leads to facial paralysis; of the hypoglossal nerve, to limited movement and hemiatrophy of the tongue. Irritation of the cervical branches may be followed by neuralgic pain and paresthesia of the neck, ear, and occiput.

Radium and **Roentgen-ray paresthesia** of the jaws and neck involves areas supplied by the trifacial, glossopharyngeal, superior laryngeal, lingual, and cervical branches, with burning, boring, gnawing, stinging, aching, almost

constant pain, preventing work or sleep. In severe cases it usually lasts about six months, when it gradually disappears.

The *treatment* is difficult and unsatisfactory. The free excision of the burned and irritated area, and the closure of the defect by plastic operation or by skin-grafting are desirable when feasible. The glossopharyngeal nerve may be exposed high under the sternomastoid, as it runs on the internal carotid, and divided or blocked by the injection of alcohol.

Distressing **paresthesia of the great auricular** and other branches of the cervical plexus follows chronic inflammatory conditions of the neck, particularly chronic fibrotic and suppurative tuberculosis of the lymph-nodes of adults. The parts are so matted and infiltrated that a satisfactory removal of the infected tissue is difficult, so, as a rule, it is better to depend on tuberculin, irradiation, heliotherapy, and injections of bismuth paste. For the relief of the pain, the great auricular nerve and adjacent branches of the cervical plexus may be blocked by an injection of from 2 to 5 c.c. of a 2 per cent. phenol solution along the middle third of the posterior border of the sternocleidomastoideus.

Unilateral division of any of the cranial nerves may occur without dangerous symptoms. When, however, both hypoglossal, both vagi, or both glossopharyngeal nerves are divided, the patient is in danger of death from suffocation unless immediate measures are taken. The division of one hypoglossal nerve leads to hemiatrophy of the tongue, with some limitation of movement but little disability. When both hypoglossal nerves are divided, the tongue no longer under control falls back into the pharynx, and may cover the epiglottis and immediately suffocate the patient; or, as liquid and solid food cannot properly be swallowed, death may occur later from the entrance of material into the trachea.

Destruction of the submaxillary ganglion or *division of the chorda tympani* produces a temporary arrest of secretion of the submaxillary and sublingual salivary glands, which may be followed in twenty-four hours by a continuous paralytic secretion. If secondary degeneration of the gland does not occur, this continuous secretion may be so troublesome as to justify excision of the submaxillary gland. Obviously, disturbances in salivary secretion may occur from disease or injury of the fibers of the chorda tympani in their course in the facial nerve, the middle ear, or while incorporated with the lingual branch of the trigeminus.

Vagus.—Besides branches to the heart, lungs, and abdominal viscera, the vagus supplies motor fibers to the levator veli palatini, and both motor and sensory fibers to the larynx. High division, therefore, is followed by paralysis of the soft palate, and paralysis and anesthesia of the larynx. Stimulation of the vagus during operation, by traction, pinching, or torsion, may produce serious symptoms and even respiratory and cardiac arrest. When exposed to operative irritation, the vagus should be blocked by applying procain or some other local anesthetic. Division of one or both nerves does not produce a dangerous effect on the heart. From one nerve there may be only a slight and transient tachycardia. Division of both nerves is dangerous, however, from its paralytic effect on the larynx. During inspiration the paralyzed cords fall together, producing asphyxia. An immediate tracheotomy or intubation may

prevent death. The division of one recurrent nerve causes hoarseness, dysphonia, and cough; division of both recurrent nerves leads to suffocation and the need of an immediate tracheotomy.

The *recurrent nerve* is most often injured during the operation of thyroidectomy. The retention of the posterior capsule of the thyroid or, better, the leaving of a thin layer of gland on each side of the trachea protects the nerve. Frazier has anastomosed the divided recurrent nerve and, with Jackson, has suggested the use of the descendens hypoglossi. Six per cent. of toxic adenomas examined at the Mayo Clinic show some degree of recurrent nerve paralysis before operation.

Fig. 666.—Sensory nerves of the neck: 1, Accessory nerve; 2, great auricular; 3, smaller occipital nerve; 4, cervical branch of the facial; 5, cutaneous cervical; 6, 7, supraclavicular nerves; 8, cervical branch; illustrating that most of the sensory nerves of the neck may be blocked by an injection along the middle third of the posterior border of the sternomastoid muscle.

Near the base of the skull, the *superior laryngeal nerve* branches from the vagus and, through the internal branch which pierces the hyothyoid membrane at the posterior border of the thyrohyoideus, carries sensation from the mucosa of the larynx. Bilateral division of these laryngeal nerves produces anesthesia of the larynx and, from loss of reflex cough, the danger of inhalation pneumonia.

Irritation of the *external* branch of the superior laryngeal nerve causes spasm of the glottis. From its location, this nerve may be damaged when one is ligating the superior pole of the thyroid. Laryngismus stridulus, from reflex irritation of the external branch or the vagus, may come from tuberculous or malignant lymph-nodes in the neck or chest, or even from gastric disease.

For laryngeal pain or spasm, the *superior laryngeal nerve* is injected before its division just above the greater cornu of the hyoid bone. A long needle is introduced in the midline of the hyothyroid space, carried along the hyothyroid membrane to the greater cornu, and an injection made of 1 c.c. of 5 per cent. phenol or 80 per cent. alcohol. This has been especially used in painful ulcerations of the larynx.

The **accessory nerve** is a motor nerve of the sternocleidomastoideus and trapezius. It enters the anterior part of the sternomastoid muscle on a line with the angle of the jaw, emerges at the junction of the middle and upper thirds of the posterior border of the muscle, and obliquely crosses the posterior triangle of the neck to enter the trapezius. It is usually injured in operations on the cervical lymph-nodes, the chief deformity being a 5 cm. *shoulder-drop*. In some patients, shoulder-drop does not occur, as there is sufficient collateral innervation of the trapezius from the cervical plexus. While paralysis of the sternocleidomastoideus alone causes little disability, it flattens the neck on the affected

side. Acute and transient *torticollis* in children is often the first evidence of tuberculous cervical lymphadenitis, the diagnosis being confirmed by the appearance of palpable nodes a few days after the onset of the torticollis. Spasmodic torticollis may be treated by injecting the accessory nerve as it enters the anterior border of the sternocleidomastoideus on a line with the angle of the mandible.

Lymph-nodes frequently suppurate in children and youth. Submaxillary suppuration follows carious teeth, periostitis, ulceration of the gums, infections of the face and parotid gland.

Ludwig's angina (Angina Ludovici, 1838—*cellulitis of the floor of the mouth and neck*) occurs especially in thick-necked and obese middle-aged men, from a streptococcal infection spreading from the mouth or tonsils. It also occurs in men between twenty and thirty years of age.

Symptoms.—Massive, brawny swelling of the floor of the mouth and submaxillary region, with tenderness, salivation, and foul breath. The skin later becomes edematous and reddened; there is difficulty in opening the mouth or protruding the tongue. The floor of the mouth is elevated, mastication is impossible, and dysphagia and dyspnea are troublesome. The *constitutional symptoms* are chills, high fever, and prostration.

Diagnosis from osteomyelitis, periostitis of the mandible, inflammations of the salivary glands is made by bimanual examination, which shows elevation of the tongue and floor of the mouth and diffuse brawny infiltration of tissues under the tongue.

Prognosis should be guarded. Death may occur within a few days from sepsis or inflammatory edema of the larynx. The pus slowly forms and may, if not evacuated, rupture into the mouth or externally. The condition is more dangerous in the debilitated, alcoholic, obese, and nephritic. *Mortality*, without free incision, is over 50 per cent.

Treatment.—The patient should be kept in a semisitting posture, antiseptic mouth-washes used, fomentation of aluminum acetate applied to the neck, tincture of iron given in large doses, with streptococcic serum and a supporting treatment. One or more free incisions are made through the submaxillary region, 1 or 2 cm. mesial to margin of jaw, with opening of deeper tissues by Hilton's method, the introduction of drains, and the application of moist antiseptic fomentations or yellow oxid-of-mercury ointment. If edema of the pharynx or larynx occurs with suffocation, tracheotomy is necessary.

Abscess of angle of jaw (*phlegmon of Chassaignac*) follows an ulceration of the mucous membrane of the mouth from the eruption of the third molar.

Treatment.—The abscess should be opened and drained, either from within the mouth or through an incision following the line of skin cleavage, medial to the angle of the jaw, by Hilton's method.

Perivascular infection of the carotid sheath follows tonsillitis, acute pharyngitis, infections of the jaws, mouth, nares, accessory sinuses, and typhoid fever.

Symptoms.—Marked swelling beneath the sternomastoid; with pain, high fever, induration, wry-neck, edema, dysphagia, dyspnea, inability to open jaws. The pus may burrow about the anterior or posterior margin of sternomastoid,

and spread under the platysma to the supraclavicular fossa or axilla or, rarely, into the anterior mediastinum along the pharynx, esophagus, or trachea.

Pathology.—The process begins as a lymphadenitis of the carotid chain (carotid lymphadenitis), followed by matting and, usually, suppuration and abscess formation.

Treatment.—(1) Avoidance of irritating applications to the mouth, pharynx, or nose, such as iodin or nitrate of silver, substituting mild gargles or mouth-washes. (2) Yellow oxid-of-mercury externally, the patient being kept at rest in bed. (3) A transverse incision is made over the anterior or posterior border of the sternomastoid for drainage (Hilton's method), as soon as there is evidence of suppuration.

Diffuse cervical cellulitis (*cellulitis of the neck*) occurs in the debilitated, alcoholic, nephritic, diabetic, after scarlet fever, and other exanthemata, and in

Fig. 667.—Actinomycosis of the neck of eight months' duration. Patient worked with cattle and had a habit of chewing straw. Healed after six months' treatment by radiation and potassium iodid. (Drs. A. Tyler and M. Wohl.)

malignant tumors; with diffuse purulent infiltration, necrosis, and abscess formation that may extend to mediastinum, axilla, trachea, esophagus, or great vessels.

Prognosis unfavorable.

Treatment.—Early multiple incisions in the infiltrated tissue. The pus tends to rupture into the common carotid, internal carotid, subclavian, inferior thyroid, and lingual, in the order given; and the eroded artery may give way at the time an incision or pressure is made, necessitating firm packing or ligation of the common carotid.

Ligneus phlegmon (woody phlegmon, Reclus' disease, 1896), a rather rare chronic progressive infection of the subcutaneous connective tissue of the neck with much induration, and little suppuration or fever, probably due to a streptococcus or staphylococcus of low virulence. It should be differentiated from actinomycosis or malignant disease.

Treatment.—Iodin or mercurial ointment locally, vaccines, opening of the small abscesses; tonic and supportive treatment.

Actinomycosis.—In frequency, the neck is involved next to the cheek and jaw.

Treatment.—Local incision and drainage, iodoform packing and internal administration of iodids, with the local application of *x*-ray or quartz light.

Acute lymphadenitis is very common from a local infection in the mouth, pharynx, nose, accessory sinuses, jaws, teeth, an adjacent cutaneous infection, or irritating applications to the pharynx and tonsils.

Prognosis favorable.

Treatment.—The primary cause should be removed, appropriate vaccines given, and local absorbents such as the yellow oxid-of-mercury ointment applied. If abscess forms it should be incised and drained, using short transverse incisions along the line of skin cleavage or a wrinkle line. The pus is evacuated, and the cavity injected with 50 per cent. red iodid-of-bismuth paste. Gauze or other packing is unnecessary. The general health of the patient should receive attention.

Tuberculous lymphadenitis usually occurs between the age of ten and twenty-five (70 per cent.). In 25 per cent. the infection is by the bovine bacillus. In children there is a tendency to liquefaction and discharge, with chronic sinuses; in older patients, to fibrosis and adhesive matting of tissue.

The inner surface of the abscess is lined with tuberculous granulations, known as Volkmann's membrane. Bacilli, which are sparse in the contained fluid, exist in numbers in this membrane.

Treatment.—(1) Tuberculin. (2) Operative removal of infecting foci in tonsils, adenoids, teeth, and the like. Operative removal of the lymph-nodes is occasionally necessary. *x*-Ray and heliotherapy are valuable. If liquefaction occurs the node should be aspirated, and equal parts of phenol and iodin or similar substances injected.

Puncture and Injection.—Calot's treatment consists of injecting sclerotic and hardened lymph-nodes through a hypodermic needle, with camphorated naphthol 2 parts, glycerin 12 parts. The injections being made every few days until softening occurs. Softened lymph-nodes are treated by aspiration, the needle being carried through healthy skin at a distance, and a solution of olive oil 70 parts, ether 30 parts, iodoform 10 parts, creosote 50 parts, and guaiacol 1 part, injected to one-half of the amount of pus withdrawn. Calot believes that the injections produce leukocytosis, phagocytosis with liberation of lipolytic ferment which attacks the fatty envelope of the bacillus, and later a proteolytic ferment having the property of liquefying and digesting the albuminoids. Protease, lipase, amylase, oxydase, complement, etc., are the enzymes formed.

The aspiration treatment is desirable to avoid scarring and extensive operative procedures. Excision of the affected glands is occasionally necessary.

Döllinger's Subcutaneous Method.—To avoid a visible scar, an incision is made along the line of the hair and the glands removed by blunt dissection from under the skin and overlying soft parts. Drainage should not be used.

Secondary plastic operation is often desirable to eliminate a disfiguring scar from a previous operation or healed sinus.

Syphilis of lymph-glands of the neck involves the submental, submaxillary region or angle of the jaw, following a primary lesion about the mouth. In secondary syphilis, the glands rarely exceed 1 or 2 cm. in diameter; are hard, movable, and painless.

Gummata of sternomastoid form nodes in the lower third of the muscle. These may be symmetric and multiple. They coalesce, but produce no disability until ulceration or sinus formation occurs.

Treatment.—Antisyphilitic, with large doses of iodids.

Blastomycetes (Busse, Gilchrist, 1894).—The infection occurs through the skin.

Symptoms.—Crusted and watery papules or indurated pustules appear upon the skin, which enlarge at the periphery. Secondary adjacent lesions develop, with minute abscesses, crusts, and bleeding granulations.

Fig. 668.—Branchial cyst of many years' standing on the right side of the neck in an elderly woman. The carotid artery and deep jugular vein are carried forward and anterior. The cyst was enucleated without difficulty from behind the lightly attached carotid sheath.

Treatment.—Excision, Roentgen ray, radium, potassium iodid given internally. Copper sulphate (Bevan), 0.015 gm. given three times daily, internally, and used as a 1 per cent. lotion locally.

Congenital serous cysts (*lymphangiectasia congenita, lymphangioma cystoides*) result from the continuous dilatation of lymphatic vessels. They are of slow growth.

Pathology.—Large and small cavities that are diffused through the subcutaneous tissues usually develop in the upper part and nape of neck, the supraclavicular fossa and upper triangle, especially along the anterior and posterior borders of sternocleidomastoideus at the level of the lower border of the jaw. The mass is rather tense, fluctuates, is smooth or nodular, and is unattached to the skin. The overlying veins may be dilated.

Prognosis is unfavorable and spontaneous cure unusual. Radical excision is very difficult on account of the size and attachments. Injections of dilute solutions of iodin, or Roentgen-ray or radium treatments may be tried.

Branchiogenic cysts usually are unilocular and derived from the third or second branchial grooves and are attached to the greater cornu of the hyoid bone or, if from the second groove, are attached to the mastoid or styloid process. They are lined by columnar or ciliated epithelium and usually contain a brownish mucilaginous fluid. The cyst is rarely noticed before puberty and forms a slowly enlarging, symmetric, fluctuating, rather soft mass lying behind and lateral to the carotid sheath, that may reach the size of an adult head. The overlying skin is not involved. Treatment is complete extirpation which, as a rule, is not very difficult. Care should be taken to avoid injury to the overlying large vessels.

Subcutaneous dermoids are rather rare in the neck where they usually

form in the branchial grooves. They contain the characteristic pultaceous, sebaceous matter and should be completely enucleated.

Blood-cysts of the neck are due to an isolated varix, a cavernous angioma, or hemorrhage into a pre-existing cyst. Temporary obliteration on pressure or enlargement on forcible expiration suggests an angioma or varix; sudden development or increase in size—a hemorrhage. The diagnosis may be confirmed by aspiration through a fine hypodermic needle.

Treatment.—(1) Compression by flannel or rubber bandage. (2) Injection of a 33 per cent. solution of quinin and urea, or ½ to 1 per cent. tincture of iodin. (3) Radical excision.

Sebaceous cysts involve the skin, frequently become inflamed, often show an enlarged sebaceous opening plugged with sebum, and should be treated by complete excision.

Cystic bursæ develop from the subhyoid bursæ situated between the hyothyroid membrane and the body of the hyoid bone. They may contain septa. Rarely, they are found above the hyoid bone, involving the suprahyoid bursa lying between the posterior insertion of geniohyoideus and hyoglossus.

Symptoms.—Tumor, 1 to 4 cm. in diameter, slowly developing, round, smooth, fluctuating. The cyst moves with the hyoid bone on swallowing, has a fixed base, is painless, and the overlying skin is normal.

Diagnosis from a branchiogenic cyst may be difficult.

Treatment.—(1) Puncture and aspiration. (2) Injection of tincture of iodin or phenol after aspiration. (3) Excision.

Echinococcus cysts of the neck are rare, and grow beneath the sternocleidomastoideus and in the connective tissue about the large vessels. The cyst may have sudden and periodic increases in size (von Bergmann), followed by subsidence and inactivity. A hydatid thrill may be palpable.

Treatment.—Excision *en masse* after the injection of a solution of formalin, iodin, or ether.

Hemangioma (Angioma Simplex).—Hemangioma may occur in any part of the neck, chiefly in the region of embryonal fissures as a *fissural angioma.*

Treatment.—Injection of 30 to 50 per cent. quinin and urea solution or of boiling water into the growth.

Cavernous angiomata, either deep or superficial, usually develop during adult life in the supraclavicular fossa, or above the hyoid bone and in the upper triangle of neck. They usually lie beneath the fascia and sternomastoid and may press on the trachea and esophagus and be mistaken for a subfascial lipoma. The diagnosis is easier if the growth pulsates, diminishes on pressure, and increases in size on forced expiration, but these signs are not constant and the withdrawal of arterial blood by a very fine hypodermic needle may be necessary to establish the diagnosis.

Treatment.—Injection of a solution of quinin and urea or boiling water. Excision may be difficult, and necessitate innumerable hemostatic forceps and ligatures for a growth 2 or 3 cm. in diameter.

Lymphangioma cavernosum is exceedingly rare. The cavities contain a characteristic milky fluid.

Solid tumors may be (a) superficial or (b) deep.

Fibroma and Neurofibroma.—The superficial include congenital elephantiasis, fibroma molluscum, and neurofibroma (von Recklinghausen's disease) developing from cutaneous nerves or blood-vessels. *Diffuse fibromatosis* (elephantiasis) is often associated with multiple spindle-shaped or nodular neuromas and with fibroma molluscum. Fibromatosis is uncommon upon the anterior part of the neck. It develops slowly, or remains stationary, but may press upon, displace, or adhere to important organs. Large fibromas occasionally grow from the ligamentum nuchæ and the vertebral aponeurosis.

Diagnosis.—Solid dense mass, of slow growth.

Prognosis favorable.

Treatment.—Excision of the fibrous masses and skin at one or several sittings; with plastic closure. Deep attachments may render the extirpation difficult.

Lipoma.—(1) Subcutaneous, (2) subfascial. May be circumscribed or diffuse. The *circumscribed* have sharp lobular outline, are usually seated in the nape of the neck, and may be symmetric or pedunculated; those in the anterior neck may be very large. Subfascial deep lipomas may be congenital, but usually do not attract attention until adult life. They are encapsulated, and tend to burrow between the muscles, large vessels, and nerve-trunks, and may surround the esophagus and trachea, and produce pressure symptoms with little external evidence of the growth. *Diffuse lipoma* (rare) occurs in middle-aged men, the neck being surrounded by symmetric collar-like masses of fat.

Diagnosis of the subfascial type may be difficult. It may be mistaken for a substernal goiter, a cyst, abscess, soft malignant tumor, or cavernous aneurysm. There is a wide, deep, diffuse mass, often bilateral with obliteration of the supraclavicular fossæ. The subcutaneous types show the characteristic dimpling, lobulation, and pseudofluctuation of fatty tumors. At the nape of the neck a hemispherical mass divided by the ligamentum nuchæ suggests a lipoma.

Treatment.—Enucleation. A diffuse lipoma may be difficult to remove. Shrinkage may be produced by repeated injections of 15 minims of alcohol (Lowenthal).

Neuroma (Fibroma Molluscum).—Occurs in the lateral region of neck, in front or behind the ear, or less frequently at the nape of neck, often in association with elephantiasis, pigmentation, or pilosis.

Treatment.—Excision.

Enchondroma and **osteoma** originate (except accessory auricles) from the cervical vertebræ, clavicle, sternum, or first rib.

Primary sarcoma develops from lymph-glands (lymphosarcoma), the aponeurotic sheaths, from the periosteum, or from adjacent bones.

Primary carcinoma develops in the skin and in the deep tissues of the neck. In skin it is rare, except as it originates in old scars. The deep form occurs in the upper triangle of the neck as the *branchial* or *branchiogenic carcinoma* (Volkmann, 1882). This is a squamous epithelial carcinoma arising between the larynx and hyoid bone, corresponding to second branchial groove or the *sinus cervicalis*, under the anterior margin of sternocleidomastoideus. The tumor extends backward beneath the cervical aponeurosis, becoming adherent to the large vessels, the vagus and sympathetic nerves. At times the growth originates in a long-standing cyst. Metastatic carcinoma should be differentiated.

Symptoms.—The mass develops in the anterior-lateral part of the neck, usually in men between forty and sixty-five years of age, on the right side. It enlarges at first slowly, then rapidly, with neuralgic pains radiating to the region of occiput and ear. Locally there is a nodular, firm tumor in the upper triangle under the sternocleidomastoideus, tending to become adherent to and to infiltrate adjacent muscles, lymph-nodes, and skin, with later rupture, ulceration, metastasis.

Prognosis.—The duration of life is from six months to a year and a half. A permanent cure is unusual.

Diagnosis is to be made from secondary metastatic enlarged glands, from other enlargements of the lymphatics, from carcinoma of supernumerary or lateral lobes of thyroid, from lipoma, tuberculosis, sarcoma, and actinomycosis. A section of an excised nodule shows squamous epithelial carcinoma.

Treatment.—Early operation is desirable, with free excision of adjacent muscle, lymph-glands, and adherent vessels. Section of the internal jugular vein, the external carotid and, at times, portions of vagus and sympathetic may be necessary. Roentgen and radium radiation may prolong or, if improperly used, shorten life and increase suffering. Recurrence, with death, within two years after excision is the rule.

Tumors of the Carotid Gland.—The *glomus caroticum*, normally of the size of a grain of corn, lies on the posterior surface of the bifurcation of carotid.

Encapsulated endothelioma of the carotid gland (potato-like tumor of the neck) forms a moderately firm, elastic mass; at first of slow growth, later showing rapid increase and a tendency to envelop the common carotid and its branches and to become adherent to the internal jugular vein and the vagus, recurrent, laryngeal, and cervical sympathetic nerves.

Diagnosis.—An ovoid, smooth, slightly lobulated swelling is present, lying under the sternomastoid at the level of the bifurcation of the carotid without implication of the skin, tending to grow upward rather than downward, and movable from side to side but not up and down. It shows transmitted but not expansile pulsation. It is to be diagnosed from lymphoma, lipoma, adenoma, tuberculous glands, sarcoma, and carcinoma. It is only moderately malignant.

Treatment.—Palliation, radiation, or operative excision. As resection of the carotid and internal jugular vein may be required, secondary cerebral symptoms may follow the operation from interference with the cerebral circulation.

CHAPTER XLI

THE ESOPHAGUS

Surgical Anatomy.—The esophagus, a musculomembranous, mucous-lined tube, 25 cm. long, extends from the lower end of the pharynx opposite the sixth cervical vertebra or lower border of the cricoid cartilage, to the cardiac orifice of the stomach opposite the tenth lumbar vertebra. Beginning in the median line of the neck, the esophagus curves 12 mm. to the left of the median line, returning to the median line opposite the fifth thoracic vertebra, and curving again to the left as it passes through the diaphragm to the cardia. The recurrent nerve lies in the groove between the esophagus and the trachea. Upon the left side are the carotid, subclavian, and inferior thyroid arteries, and the thoracic duct. In the chest to the left lie the aorta and the pleura, and on the right side the azygos vein and, more closely, the pleura. In front are the lower trachea, the left carotid, the subclavian, the arch of the aorta, the left bronchus, the left pneumogastric nerve, and below, the pericardium. Behind are the thoracic duct, the intercostal arteries, the right vagus nerve, the descending aorta and, near the diaphragm, the azygos vein.

The *blood-supply* for the upper portion of the esophagus comes from the inferior thyroid artery; for the lower, from the aorta, the intercostal and gastric vessels.

The *nerve supply* is from the sympathetic and vagi.

The *lymphatic vessels* of the esophagus empty into the mediastinal lymph-nodes.

The *caliber* of the empty esophagus is about 2 cm., except at the points of constriction, where it is about 12 mm. The esophagus is easily dilated to more than twice these diameters.

Normal constrictions are found (a) 15 cm. or 6 inches from the incisor teeth, opposite the cricoid cartilage; (b) 27 cm. or 12 inches from the incisor teeth, at the bifurcation of the trachea, and (c) 37 cm. from the incisors, at the hiatus where the esophagus passes through the diaphragm. The cardia is 40 cm. from the incisors.

Diagnosis.—In esophagitis, esophageal obstruction or dilatation, there is dysphagia or difficulty in swallowing. Usually there is substernal pain, radiating to the back, which is induced or aggravated by taking food. Vomiting or regurgitation of food and saliva is common when obstruction or diverticula are present. Food may be vomited immediately or, if the esophagus is greatly dilated, after an interval of a few minutes or several hours, in which case it is often alkaline, odorous, and decomposed. Usually the patient can take only a very small quantity of food at a time.

Clinical Examination.—*Inspection* may show a swelling of the neck, enlarging on deglutition from a diverticulum.

Auscultation.—The normal swallowing time is seven seconds. In disease, the sound produced by the entrance of food into the stomach after swallowing, as determined by the stethoscope at the ensiform, is delayed or absent.

Radiography.—It is best to precede the introduction of instruments into the esophagus by a Roentgen examination. Bismuth, barium, or other substance opaque to the rays should be given: (1) Dissolved or suspended in a liquid, such as water or buttermilk; (2) stirred in a bolus of jam, marmalade, or porridge; or (3) in large gelatin capsule, which is most important (Pancoast). Fluoroscopic examination should include the oblique and horizontal planes. Not only should evidence of ulcer, obstruction, spasm, stricture, diverticulum, or tumor of the esophagus be sought, but the examination should con-

sider the possibility of aneurysm, dilatation of the heart, neoplasms of the neck, mediastinum or lung, enlarged lymph-nodes, and mediastinal or spinal abscess. A preliminary radiographic study may prevent the perforation of a stricture or diverticulum, or the rupture of an aneurysm by the introduction of a bougie or other instrument.

Esophagoscopy.—Inspection of the interior of the esophagus is made directly by the use of the esophagoscope—a long narrow tube carrying a small electric light in the distal end. Through this tube, not only may the esophageal lining be examined from the pharynx to the stomach, but foreign bodies may be located and removed, and bits of tissue taken by punch forceps or small curet for microscopic study.

Percussion elicits resonance over an air-distended and greatly dilated esophagus, or dulness over a fluid-distended diverticulum.

Palpation is carried out by means of flexible plastic wax or stiff bougies or tubes introduced through the mouth or a gastrostomy opening.

Fig. 669.—Jackson's esophagoscope or gastroscope.

Congenital malformations are rare: 1. *Agenesis.*—The esophagus is partially or completely absent, or represented by a solid fibrous cord, with or without an upper and lower culdesac. Usually the esophagus ends at the bifurcation of the trachea. A lower segment may arise from the trachea or bronchus and open into the stomach.

2. *Esophagus Duplex.*—The esophagus partially or completely double.

3. *Congenital Atresia or Stenosis.*—The esophagus, especially the lower portion, is blocked wholly or partially by a diaphragm. Hirsch collected 146 cases of congenital stricture.

4. *Esophagotracheal* or *esophagobronchial fistulæ*, due to incomplete closure of the branchial clefts, are the most common congenital anomalies. (a) The upper third of the esophagus may be represented by a pouch, the lower portion communicating with the trachea or bronchus; or (b) the upper end may enter the trachea, and the lower end also enter the trachea at a different level; or (c) a side-to-side fistula may exist between the trachea and the esophagus.

5. *Congenital diverticula* are rare, usually small, and located in the upper part of the esophagus, near the level of the clavicle. As they grow, they press upon the trachea, producing dyspnea.

Symptoms.—*Dysphagia.* If there is obstruction, the food is regurgitated unchanged and without admixture with the acid gastric juices. If there is communication with the trachea or bronchus, swallowing is followed by dyspnea,

cyanosis, and suffocative cough from the entrance of food or liquid into the trachea and lungs.

Treatment.—Congenital absence or complete stenosis of the esophagus should be treated by an immediate gastrostomy and, later in life, an esophageal tube may be constructed to run between the skin and bony chest wall, from the esophagus in the neck to the stomach. If a stricture is present, this should be gradually dilated by bougies guided by a swallowed thread. *Esophagotracheal* or *esophagobronchial fistulæ* are to be treated by a two-stage operation, if the lesion can be reached through the neck; or, by a cervical esophagostomy and gastrostomy. With the latter, the cervical esophagus is divided, and brought out through an incision in the neck to avoid the entrance of food and saliva into the lungs, and the patient is fed through the gastrostomy opening.

Traumatic Injury.—*Foreign bodies* are swallowed deliberately by children, by the insane, and by exhibitionists; or accidentally in gluttonous eating or from

Fig. 670.—Roentgenogram showing a jack-stone in the upper end of esophagus. For three weeks the child had not been able to take solid food, although liquids were easily swallowed. (Roentgenogram by Dr. G. C. Bird.)

objects placed in the mouth. The esophagus may be *obstructed* by large boluses of meat or other food, dentures, coins, knives, forks, marbles, or toys. It may be *punctured* or *lacerated* by safety-pins, fish- or meat-bones, bits of glass; by the passing of bougies, stomach-tubes, esophagoscopes or other instruments, or by swords and similar articles introduced by exhibitionists. It may also be injured by external violence from gunshot, shrapnel, cut-throat, and severe crushing injuries. Rupture of the esophagus usually occurs just above the cardia. Foreign bodies, not caught in the pharynx, usually lodge at the level of the suprasternal notch just above the arch of the aorta, where, after three or four days, they often ulcerate through the walls of the esophagus into the aorta, carotid, or other large vessel, causing a fatal hemorrhage. The long axis of the foreign

body lies transversely in the esophagus, sagittally in the trachea. Coins up to the size of a quarter usually pass through the esophagus, even in children. If the esophagus is perforated or ruptured without serious hemorrhage, a secondary periesophageal abscess and usually a fatal mediastinal abscess with possible associated empyema rapidly follow.

Symptoms.—A foreign body lodged in the esophagus causes aphagia or dysphagia, dyspnea, and substernal pain which usually comes on soon after the body is swallowed. In case of doubt, the pharynx should immediately be explored by the finger and, if found free, the esophagus should promptly be examined by means of the esophagoscope. If an esophagoscope is not available, and the foreign body is not too large or sharp, it may be pushed down into the stomach by means of a sponge probang or a bulbous bougie, or withdrawn into the mouth by means of a bristle probang or coin-catcher. If the esophagus has been punctured, lacerated, or ruptured, it should immediately be exposed in the neck or by mediastinotomy; the wound sutured, and any infected areas appropriately isolated and drained by gauze and tubes.

Rupture of the esophagus occurs: (1) From *esophagomalacia* due to prolonged vomiting or repeatedly induced vomiting; (2) as a *result of instrumentation*, the passage of sounds, bougies, and tubes through the esophagus, and (3) from *swallowed foreign bodies.*

Symptoms.—Rupture is followed by severe pain, hsock, vomiting of red blood or black or brownish fluid, with evidences of secondary mediastinitis.

False passages occur most frequently (a) through the *bottom of a diverticulum* when entered by a bougie or tube; (b) in the *upper thoracic portion* on the left wall, where it turns from left to right at the level of the bifurcation of the trachea; and (c) in the *lower thoracic portion* on the right wall, where the esophagus turns from right to left above the diaphragm. Perforation is followed by hemorrhage, dysphagia, and the escape of fluid into the mediastinum, with secondary abscess formation and usually a fatal sepsis.

Symptoms.—There is immediate, violent substernal pain, radiating to the back or epigastric region, with the rapid development of symptoms of mediastinitis or purulent pleurisy.

Treatment consists in an immediate gastrostomy, a cervical esophagostomy, or esophagorrhaphy so that swallowed fluid may not leak through the point of rupture, and the isolation and drainage of the affected area of mediastinum and pleura through a mediastinotomy, by gauze and tubes.

Burns (Corrosion).—The esophagus is burned by the passage of hot liquids, but more frequently by the ingestion of caustics and alkalies. Lye in liquid or powdered form is frequently swallowed by children; carbolic acid, mineral acids, bichlorid tablets, and other corrosives by accident or suicidal intent. Appropriate antidotes, as vinegar or lemon juice for corrosive alkalies, sodium bicarbonate or lime-water for the corrosive acids, 40 per cent. alcohol or soluble sulphates (Epsom or Glauber's salt) for phenol—should immediately be given, followed by olive oil, white of egg, flaxseed tea, or other demulcent. The deepest burn usually is at the hiatus, just above the diaphragm where the caustic is retained for the longest period of time. Secondary necrosis, ulceration, suppuration and, later, stricture or atresia follow. If the injury is severe, the esophagus

should at once be put at rest, and a gastrostomy or jejunostomy used for the administration of nourishment. For fear of perforation or rupture of the esophagus, lavage and bouginage should be delayed until healing is well advanced.

Esophagomalacia is an antemortem softening of the esophagus.

Pathology.—The condition is due to frequent vomiting or the regurgitation of erosive gastric fluids, and involves the lower half of the esophagus, with erosion, ulcer, abscess, rupture, hemorrhage, stricture, or atresia of the esophagus.

Etiology.—1. *Vomiting:* (*a*) Vomiting of pregnancy. Vinson reports 9 cases with secondary stricture or other lesion of the esophagus. (*b*) Postoperative vomiting may likewise injure the esophagus and, from the strain of vomiting, the damaged esophagus may rupture.

2. *Toxemia* and *blood dyscrasia*—as in nephritis and acute infections, including scarlet fever, pyemia, typhoid fever, and smallpox—may be associated with esophagomalacia.

Symptoms.—Substernal or epigastric pain, burning sensation, and the vomiting of a dark brownish (*coffee-grounds*) or blood-stained fluid with mucus, or of pure blood, are the chief symptoms. If an interstitial or periesophageal abscess forms, pus may be vomited. The patient may recover with or without a stricture, or die from rupture or secondary hemorrhage.

Treatment should be prophylactic. The frequent use of alkaline demulcent drinks, such as magma magnesiæ, mucilage of acacia, or flaxseed tea alkalinized with citrate or bicarbonate of soda is advised. In severe, resistant cases with evidence of esophagomalacia, a gastrostomy or jejunostomy should be done.

Hemorrhage from the esophagus may be due to: (1) *Trauma*, most frequently from ulceration of foreign bodies into adjacent blood-vessels, occasionally from wounds or the passage of a bougie or stomach-tube; (2) *ulcer of the esophagus*, usually from carcinoma, more rarely from tuberculosis or syphilis; (3) *blood dyscrasia*, severe anemia, Banti's disease with erosion and severe hemorrhage; (4) *varicose veins*, usually at the lower end of the esophagus, found chiefly in alcoholics, and with cirrhosis of the liver.

Rapidly fatal hemorrhage occurs from the subclavian, pulmonary, the superior vena cava, the descending aorta, or from the carotid or inferior thyroid artery, the azygos or varicose veins.

Treatment is rarely of any avail if a large artery has been opened. The patient, walking about with a foreign body lodged in the esophagus, suddenly falls to the ground with blood gushing from the mouth, and dies within a few moments. From varicose veins, the hemorrhage is usually violent and not infrequently fatal. The hemorrhage from carcinoma or other forms of ulcer is usually less severe, and is controlled spontaneously or by treatment. The earliest possible removal of foreign bodies, particularly those that are large, hard, and irregular, should be practised. Blind bouginage, or the introduction of a tube or instrument into the esophagus in the presence of an aortic aneurysm, necrosis of the walls of the esophagus as after corrosion, or where there is reason to suspect ulceration or varicosity should be avoided. If the patient does not immediately die from the violence of the hemorrhage, he should be placed in the Volland position with an ice-cap over the lower sternum, and

nothing given by mouth except small quantities of epinephrin, kephalin, glycerite of tannin, or emulsion of turpentine. Stimulants that may increase the blood-pressure should not be used. If the esophagus is seriously diseased, it is wise to put it at rest by a gastrostomy. Serum may be given subcutaneously and typed blood and calcium chloride intraveneously.

Esophagitis.—(1) *Acute catarrhal esophagitis* occurs in the specific exanthematous fevers, and as an idiopathic affection in infants. (2) *Traumatic:* May be due to foreign bodies and ingested corrosive substances. (3) *Infectious membranous esophagitis:* In diphtheria and severe toxemia, in typhoid, scarlet fever, smallpox, and other exanthemata. Thrush involves the esophagus in infancy. (4) *Ulcerative:* Peptic ulcers occur in the esophagus from chronic vomiting, also in typhoid fever, diphtheria, debilitating disease, and in aneurysm. (5) *Malignant* as in carcinoma. Secondary rupture of the esophagus is exceedingly rare.

Fig. 671.—Cardiospasm with enormous secondary dilatation of the esophagus. The constriction is shown at *a*. There is no filling defect. (Carman.)

Periesophagitis, with a low-grade inflammation and obstruction, is associated with mediastinitis such as follows pneumonia or appendicitis.

Treatment is that of the underlying condition and of the complications.

Esophagismus (Spasm of the Esophagus).—Physiology.—The longitudinal muscular fibers of the esophagus are innervated by the vagus, and on contraction open the cardia. Incoördination between the peristaltic wave and the contraction of the longitudinal muscular fibers will lead to idiopathic dilatation. Rarely cardiospasm with hypertrophy of the sphincter is present. Angulation or kinkage of the lower end of the esophagus may aid in the obstruction.

Etiology.—Spasmodic contraction of the esophagus occurs in diphtheria, in hyperchlorhydria, and hydrophobia. Idiopathic dilatation of the esophagus results from spasm of the cardiac end. Usually there is dilatation of the lower two-

thirds of the esophagus and hypertrophy of the muscular wall, without hypertrophy of the cardiac sphincter. There is a transient delay in the passage of the bismuth meal from the esophagus into the stomach.

Cardiospasm from contraction of the circular muscle is usually associated with atony and lack of muscular tonus in the walls (muscular incompetency) and dilatation of the esophagus.

Symptoms.—Pain which may be paroxysmal, radiating to the sternum, back, throat, and ears.

Diagnosis.—In carcinoma, the obstruction precedes the pain; in cardiospasm, pain precedes the dysphagia. Radiography may show little evidence of obstruction, while dilatation produces the characteristic pain. Epigastric pain occurs in two-thirds of the cases, and may simulate gall-bladder colic and require a hypodermic. In one of Vinson's patients occasional attacks continued for fourteen years before the onset of dysphagia.

Treatment.—The treatment of functional atresia, or stricture of the esophagus, is the treatment of the underlying condition, including a neurosis. If a reflex cause can be located, this should be removed.

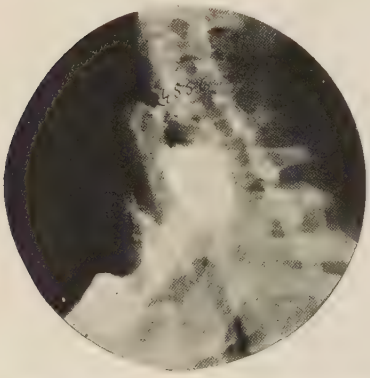


Fig. 672.—Barium-filled diverticulum of the esophagus (Carman).

In cardiospasm a thread is swallowed which serves as a guide for a hydrostatic dilator. A single thorough dilatation to from 24 to 48 F. usually gives complete relief.

Paralysis of the esophagus occurs rarely in bulbar paralysis and in diphtheria. There is dysphagia without regurgitation of food.

Treatment consists in the use of the stomach- or duodenal-tube, or a gastrostomy.

Diverticula are sac-like protrusions of a part of the wall of the esophagus, and are divided into *pulsion* and *traction* diverticula.

1. **Pressure** or **pulsion diverticula** usually develop on the posterior wall of the esophagus, near the junction with the pharynx, where the muscular wall is weak and yields from the pressure of swallowed foods, forming a pouch on left side of the neck. It frequently develops in elderly men and, as the opening in the diverticulum is in the axis of the esophagus, swallowed food is diverted into the new sac, with compression of the adjacent esophagus and difficulty in introducing food into the stomach.

Symptoms are dysphagia, progressively increasing with a sense of pain and pressure, a mass in the neck, and the regurgitation from time to time of the foul, decomposing, alkaline contents of the sac.

Prognosis is serious, as inanition or perforation into the mediastinum or the pleura may occur with fatal result. Care should be taken in the introduction of instruments, to avoid perforation of the diverticulum.

2. **Traction diverticula** occur on the anterior wall of the esophagus, near the bifurcation of the trachea, from the pull of adjacent adherent lymph-nodes, lung, pleura, or the like. The sac rarely exceeds a few centimeters in diameter,

and no symptoms may be noted unless perforation occurs. These small traction diverticula also may be perforated by a stomach-tube or bougie.

Treatment.—(a) Swallowed thread, as a guide for swallowed food and the introduction of instruments. (b) Irrigation of the cavity by boric acid solution, or a weak solution of permanganate of potash. (c) Wearing of Symond's tube. A string is attached, and the tube changed every ten days to two weeks. (d) Excision and suture if the diverticulum is large, located in the neck, and cannot be made to contract. To prevent mediastinal infection the operation should be done in two stages; the sac being anchored in the wound of the neck in the first stage, and excised one or two weeks later (Lahey). (e) Gastrostomy is used to prevent starvation.

Esophagobronchial Fistula.—Etiology.—An opening between the esophagus and bronchus may be congenital, may follow gunshot or other wounds or an ulcerative or septic process, from cancer, actinomycosis, or a foreign body.

A swallowed thread may pass through the fistula into the bronchus, be coughed up and reswallowed, "looping the loop" repeatedly, and then be very difficult to withdraw or remove.

Treatment.—(1) If in the neck, separation and plastic closure of the opening may be attempted. (2) Gastrostomy associated with a proximal cervical esophagostomy.

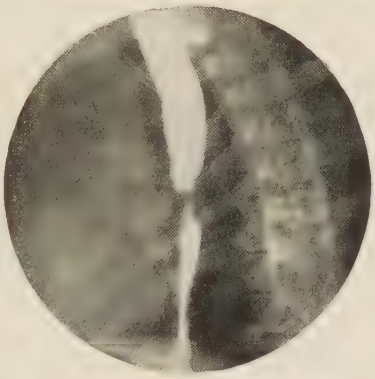


Fig. 673.—Carcinomatous stricture of the esophagus (Carman).

Stricture and Stenosis.—An obstruction of the esophagus may be (1) *intrinsic*, arising in the walls of the esophagus, or (2) *extrinsic*, arising from without, (a) relative or (b) absolute.

Intrinsic or *Obstructive Stenosis* or *Stricture:* (1) Congenital or developmental, from malformation. (2) Corrosive, from the swallowing of caustic acids or alkalies (25 per cent.). (3) Inflammatory or cicatricial, from peptic ulcer of the cardia or esophagomalacia, or from diphtheritic, syphilitic (rare), tuberculous (rare), or phlegmonous esophagitis. (4) Paralytic, from bulbar palsy or after diphtheria. (5) Functional or spastic (*esophagospasm*), from neurosis, reflex causes, bulbar palsy. (6) Neoplastic, from tumors, including polyps and carcinoma (50 per cent.).

Extrinsic or *compression stenosis* results from: (1) Lymphomas, inflammatory or neoplastic enlargement of the mediastinal lymph-nodes. (2) Thoracic aneurysm. (3) Hyperplasia of the intervertebral cartilage. (4) Spinal curvature. (5) Effusive or adhesive pleuritis or pericarditis. (6) Thyroid tumors or enlargement. (7) Mediastinal tumors, exudate, or abscess.

Site.—Stricture or stenosis of the esophagus frequently occurs: (1) At normal points of narrowing as at the entrance of the esophagus. (2) Opposite the bifurcation of the trachea. (3) Opposite the diaphragm. Caustics are usually retained in the hiatus, and therefore produce the deepest effect and most marked stricture just above the cardia. Syphilitic strictures usually develop in the upper esophagus; carcinomatous strictures about the hiatus, just above the

diaphragm. Phlegmonous esophagitis causes widespread stricture. Spastic strictures (cardiospasm), varying in intensity and location, occur in neurotic and hysterical persons.

Varieties.—*Caustic strictures* (*superficial* and *deep*) are: (1) Trabeculated. (2) Linear. (3) Crescentic. (4) Valvular or semilunar. (5) Annular (2 or 3 cm. in length), or (6) tubular (5 to 10 cm. in length).

Secondary changes consist in: (1) *Muscular hypertrophy* and thickening of the esophagus above the stricture. (2) *Muscular insufficiency* and dilatation of the esophagus. (3) *Static esophagitis* which may progress to ulceration and suppuration, from accumulation and decomposition of food above the stricture. The esophagus may be distorted or kinked by adjacent adhesion.

Symptoms.—The symptoms of esophageal stricture are dysphagia, or aphagia with regurgitation of food, mucus, and swallowed saliva. With organic stricture, the first difficulty is usually noted with the swallowing of meat, then bread, potato, soft food, and finally even liquids cannot be taken. The organic stricture is constant, the symptoms of obstruction showing a slight variation from local swelling. Functional or hysterical stricture varies from day to day, and the patient will often swallow meat, potato, and solid food, but have difficulty in swallowing liquids. Functional stricture of the esophagus is frequently due to phrenospasm, an excessive stimulus coming through the phrenic nerve, causing spasm of the diaphragm, and obstruction at the hiatus œsophageus. The esophagus above the hiatus may be markedly dilated, with a marked curve at the lower end to the left shown on Roentgen examination. In peptic ulcers of the cardia the onset is usually slow, the patient anemic or alcoholic, and in the early stages there is pain immediately after swallowing, with obstruction.

Mal d'engasgo is an endemic form of cardiospasm producing dysphagia, occurring in Brazil and other tropical countries. It should be treated by hydrostatic dilatation of the cardia or, if this fails, the more dangerous Jeller's operation or a bilateral longitudinal division of the circular muscular fibers of the cardiac end of the esophagus may be considered.

Diagnosis.—Congenital obstructions are found at birth. Swallowed caustics (lye) are the most common cause of stricture of the esophagus in children, and give symptoms of long duration. Carcinoma is the most common cause of obstruction after middle life, and has symptoms of short duration. The diagnosis is verified by Roentgen examination, by the esophagoscope, or by the careful use of bougies.

Prognosis.—Stricture from cicatricial tissue, formed after intense caustic erosion or severe ulceration, tends to progress to complete occlusion. From the unskilful passage of instruments, false passages, ulceration, periesophageal suppuration, or hemorrhage may occur and be fatal. Cancerous strictures often increase to complete occlusion.

Treatment.—Organic stricture without malignant change is treated by:

1. The *swallowing of a thread:* Five meters of size 0 buttonhole twist silk is slowly swallowed by the aid of water or other liquid, one end being retained and fastened to a tooth or, by adhesive plaster, to the cheek. In children it may be necessary to use a catheter through the nose, the thread being washed from a funnel through the catheter by a small amount of water from a syringe. The

lower end of the thread will eventually find its way through even a very small and tortuous opening, and pass through the stomach and into the intestine. The thread serves as a guide for the introduction of instruments and, by constant pressure and tension from peristalsis, enlarges the opening through the stricture. It may be worn with renewals for many weeks, 1 or 2 meters of fresh thread being swallowed daily, and any portion hanging from the anus being cut off. After use the thread is cut and permitted to pass. Often the patient will have marked relief from the wearing of the thread alone.

2. *Bouginage:* For simple fibrous strictures bougies are cautiously tried six to eight weeks after the injury. If the wall of the stricture is covered by normal mucosa, the stricture may be gradually and permanently dilated by the use of graduated bougies. Rapid dilatation or divulsion is dangerous, and should not be employed. An olivary bougie is passed on a thread as a guide at increasing intervals of a week, ten days, two weeks, six weeks to three months, and thence once yearly for two or three years. At the first treatment a dilatation to 30 F. is usual, and by the end of the year 45 F. If the stricture is very dense and undilatable, a heavy linen thread or bass fishing line may be introduced through the mouth and out through a gastrostomy opening, the stricture being enlarged by carefully sawing the thread back and forth (Abbe's method) or, better, by pulling soft rubber dilators through the stricture, and leaving them in place for twelve hours or more. If the thread cannot be introduced by swallowing, a piano wire with a minute ball at the end may be very carefully introduced (Vinson). If the stricture is long, narrow, and very tortuous, retrograde bouginage through a gastrostomy opening, as by Tucker's bougie, is to be preferred to the peroral route. If there is complete occlusion, retrograde and peroral bouginage may be combined, the distance between the two instruments being determined by the roentgenogram, and the esophagus tunneled from below. A thread may be introduced from below, and should be worn constantly until complete dilatation has been produced.

If the walls are entirely cicatricial, regular dilatation throughout the patient's life may be required. In atresia, if the patient is in serious condition from water and food starvation, this should first be relieved by the free use of saline under the skin, the intravenous and rectal use of glucose solution, and possibly the transfusion of blood. Gastrostomy should then be done to enable the patient to be fed, after which examination of the patient and treatment of the stricture may be attempted.

Secondary malignant change from simple stricture is rare. The mortality of instrumentation is about 5 per cent., and 2 per cent. of the patients require a gastrostomy.

For **phrenospasm** that cannot otherwise be relieved, the phrenic nerve is exposed, stretched, injected with a 2 to 5 per cent. solution of phenol, or frozen for thirty to sixty seconds by the ethyl-chlorid spray.

Carcinoma is the great cause of esophageal obstruction after the age of fifty. Seven per cent. of carcinomas involve the esophagus, which is fifth among the organs in order of involvement. Usually the middle or lower third of the esophagus is affected, not infrequently the upper third in women.

Pathology.—The growth is an epithelioma, usually originating in the lower

third of the esophagus. The cancer may remain localized to the esophagus for many months, and then spread to the cervical and lymphatic glands, the adjacent bronchi, pleura, lung, and other structures. Seventy-five per cent. metastasize.

Etiology.—(1) *Sex:* Men are affected five times as frequently as women. (2) *Age:* Thirty-five to eighty years. Ninety-five per cent. occur in men at an average age of sixty years. (3) *Oral sepsis.* (4) *Chronic bolting* of food. (5) *Previous injury* or burn of the esophagus. A preceding stricture of the esophagus is uncommon.

Symptoms.—A. *Early:* (1) *Dysphagia*, progressive and increasing, and at times of sudden onset. (2) *Hiccup* may occur early. (3) *Regurgitation* of small amounts of food and mucus immediately after swallowing food is an early symptom; the regurgitation is rarely delayed and profuse as in cardiospasm. With a high postcricoidal lesion, the constant expectoration of thick mucus occurs.

Fig. 674.—Carcinoma of the esophagus, filling defect, irregularity and obstruction shown at *a* (Carman).

B. *Later:* (1) *Pain*, usually substernal or epigastric, occurs rather late and follows dysphagia. (2) *Emaciation* from starvation appears rather than cachexia. (3) *Hoarseness* from pressure on the recurrent nerve, and hemorrhage and perforation chiefly occur in the terminal stage.

Diagnosis.—Ninety per cent. of strictures of the esophagus starting after the age of forty without evidence of previous injury to the esophagus are malignant. Radiographic and esophagoscopic examinations are valuable but not infallible. Tissue removed through the esophagoscope may show malignancy or only inflammatory change, the malignant infiltration lying below or to one side of the area sectioned.

Prognosis.—Cancer of the esophagus is rather low in degree of malignancy,

being less than that of cancer of the colon; nevertheless it is almost invariably fatal, less than a dozen successful esophagectomies are on record. The usual duration of life is about eighteen months. Death occurs from starvation, perforation, bronchopneumonia, or metastatic growths.

Treatment.—*Radical Esophagectomy:* Carcinomas of the introitus, the middle third and the lower esophagus, have in a few instances been successfully removed. The upper through a cervical incision; the lower two by a posterior mediastinotomy, with or without an associated abdominal incision. The great danger from the operation is mediastinal and pleural infection. The proximal end of the esophagus is brought out through the neck (*cervical esophagostomy*), the patient is fed through a gastrostomy opening, and later the stump of the esophagus and the gastrostomy opening connected by a rubber tube or by a tunnel formed in the subcutaneous tissues of the chest, and lined by skin or mucous membrane.

In the *Roux method* a loop of jejunum is implanted under the skin over the chest wall, from the neck to the abdomen. At a second stage the lower end of loop is anastomosed to the stomach, to be followed later by division of the esophagus in the neck and the anastomosis of the proximal end with the jejunal loop. The distal end of esophagus is closed.

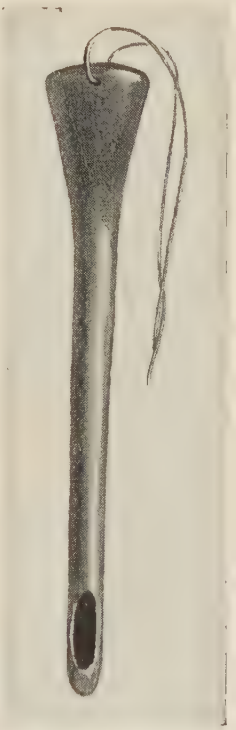


Fig. 675. Symond's tube, worn for diverticula and strictures of the esophagus.

Palliative Treatment.—(1) Dilatation: The wearing of a swallowed thread usually gives some relief to the obstruction. Dilatation to 45 F. by the passage of olivary bougies on a swallowed thread as a guide, affords relief for five to eight weeks with a mortality of 3 per cent. from rupture or perforation of the esophagus, and an average duration of life of five months under the treatment. For carcinoma at the cardia dilatation gives little relief. (2) Intubation of the malignant stricture by Symond's gum-elastic or similar tube introduced with an attached thread, to be removed and reintroduced about every two weeks, is somewhat hazardous and rarely desirable. (3) Gastrostomy overcomes the starvation, puts the esophagus at rest, and usually is followed by a spontaneous opening of the esophagus so that the patient is able to resume feeding by mouth. It has a mortality of about 10 per cent. largely due to the patient's enfeebled condition.

Radiation is of no value in treating carcinoma of the esophagus.

If an esophagotracheal fistula forms, a gastrostomy should immediately be done and, in certain cases, an associated cervical esophagostomy to prevent leakage of swallowed fluids into the lung. Perforation of the esophagus into the mediastinum or pleura usually is fatal and, in view of the associated hopeless condition of the patient, rarely justifies operative treatment.

CHAPTER XLII

THE THORACIC WALL

ANOMALIES

Congenital anomalies of the thoracic wall are common, and often involve the sternum.

Clavicles may be deficient (especially in their outer portion) or absent, permitting the shoulders to be nearly or completely apposed in front. The defect usually causes little disability.

Funnel-chest (*funnel-breast*, *pectus excavatum*) is characterized by a depression or groove in the front of the chest, involving the sternum and the adjacent costal cartilages. Usually congenital, asymmetric and in males; it is not due to rickets, and has been ascribed to the pressure of the knees *in utero*.

Treatment.—In children especially, tonsils, adenoids, or other impediments to free respiration should be removed, and ample diet, fresh air, and sunshine provided. Breathing exercises and those that develop the pectoral and other muscles, expanding the chest and holding the shoulders back, should be given. If the deformity is very objectionable, or produces pressure upon the intrathoracic organs, the sternum may be split in the midline and also transversely at the upper margin of the deformity, elevated, the edges everted with division, if necessary, of sufficient number of the ribs or adjacent costal cartilages to overcome the deformity. The fragments may be fixed in position by strong sutures, silver wire, or bone or ivory pegs or inlays. The operation is too serious for any but extreme cases.

Pigeon-breast (*chicken-breast*, *pectus carinatum* or *gallinatum*) is characterized by the projection forward of the sternum and costal cartilages, like the chest of a bird. The condition may be congenital, but frequently is acquired from rickets associated with obstruction to inspiration by enlarged tonsils or occluded nares; it also results from dorsal Pott's disease, and paralysis of the muscles of the trunk. The deformity is usually asymmetric, and seldom causes symptoms. In the growing child, exercises should be used to develop the sides of the chest, and a padded spring-truss may be worn to press the sternum backward.

Defects of the Sternum and Ribs.—Fissure of the sternum is the most common defect, usually involving the upper part or the ensiform (*bifid ensiform*) or the lower part (*processus xiphoideus bifidus*). It may cause a large oval opening in the sternum, or divide the bone into two halves, which separate, especially at the upper part, on inspiration. More rarely there is aplasia or absence of the sternum, the absent bone being replaced by a fibrous membrane. The lower defects may be associated with an epigastric hernia, the higher defects with herniation of the heart or lung. With the lung, a vesicular murmur and emphysematous crackling on reduction may be present.

Ribs.—Excess in the number of ribs occurs in the cervical or, rarely, in the lumbar region. One or more ribs may be absent, defective, or fused; the defect usually being in the anterior part. Anomalies in the number, and in the union of the costal cartilages of the ribs occur. Fissured thorax may result from defects of the ribs near the sternum (*fissura thoracis parasternalis*) or laterally (*fissura thoracis lateralis transversa*). Congenital hernia of the lungs occurs through these defects, producing a tympanitic swelling that enlarges on expiration. In Freund's case, a deep transverse groove from sternum to spine was due to absence of the fourth, fifth, and sixth ribs.

Treatment.—A pad, bandage, or truss is used; or in extreme cases operative correction with the implantation of fascia, muscle, bone, or cartilage.

Muscular Defects.—Muscles of the chest wall—the pectoralis major, the intercostals, the transversus thoracis (triangularis sterni), the latissimus dorsi, the scapular muscles, or the serratus anterior—may be imperfectly developed or entirely absent. Occasionally supernumerary muscles, such as the costocoracoid, the costo-epitrochlear, or the sternalis, are present.

Twin monsters usually are fused at the thorax (*thoracopagus*). In *sternopagus* or *sternodymus*, the twins are united in the region of the sternum. In *xiphopagus* the double monster is joined at the thorax and pelvis.

Surgical separation of such twins, as by xiphopagotomy, may be difficult or impossible because of the presence of a common liver, pericardium, pleura, or other vital organs. Before separation is attempted, all possible tests (including a Roentgen study) should be made to determine the possibility of each twin being able to function alone.

Fig. 676. Xiphopagous twins, "Maria-Rosalina," about twelve years old. (After Baudouin.)

The death or incurable illness of one twin may necessitate an immediate separation to save the life of the other, as in the case reported by Doyen with Radica and Doodica.

Acquired Malformations of the Chest.—Acquired and developmental changes in the chest are common. *Flat chest* is one with narrow anteroposterior diameter. A long, narrow, poorly developed chest is frequently seen in the tuberculous. *Barrel-chest*, round, large, and with limited inspiratory capacity, is characteristic of chronic emphysema. *Constricted*, *hour-glass*, or *corset chest* may follow tight lacing.

Lordosis of the thoracic spine produces deformity of the chest. Kyphosis of the thoracic spine follows destruction of the vertebral bodies, as from Pott's disease, and results in marked deformity of the chest, with approximation of the ribs and decrease in the respiratory capacity. *Scoliosis* of the thoracic region produces an asymmetric deformity.

Intrathoracic disease, especially when associated with collapse of the lung, adhesive pleurisy, or empyema, may cause marked deformity of the thoracic wall.

Fig. 677.—Diffuse emphysema chiefly involving the chest, neck, and head following puncture of the lung by a fractured rib.

INJURIES OF THE THORAX

Contusions.—In the sudden application of force without the division of the skin, the elastic chest walls yield before the violence, compressing, bruising, or lacerating the contained organs, and affecting the lungs, heart, great vessels, trachea, or diaphragm, with occasional secondary effects on the liver, spleen, kidneys, and intestines.

From *injury of the lung* there may be shock with pallor or marked cyanosis, dyspnea, bloody froth at the mouth, and escape of blood or air into the pleural cavity.

Rupture of the trachea or of the large vessels of the neck or heart is, as a rule, rapidly fatal.

Laceration of the diaphragm with diaphragmatic hernia is frequently overlooked, the patient at times living for years without very evident symptoms.

Traumatic emphysema of the subcutaneous tissues, with grotesque distention of the skin of the thoracic walls, neck, head, extremities, may rapidly follow when a broken rib has lacerated the lung. Palpation elicits characteristic crackling. Emphysema of the mediastinum may seriously affect respiration and circulation. In a few days the subcutaneous emphysema usually spontaneously disappears.

Traumatic cyanosis occurs from severe compression of the chest, as from run-over or elevator accidents. As the veins of the neck and head have no valves, hemorrhages in the skin, conjunctivæ and orbits, and temporary loss of vision may

follow with swelling and great cyanosis of the head, face, neck, and upper chest. The appearance is striking with the blood-red conjunctiva, and with the purple (almost black) skin extending in "doll's head" area. A sharp line of demarcation is present about the upper part of the chest. Although the condition is serious, recovery frequently follows. The cyanosis may rapidly clear, although the sclera remains discolored for five or six weeks. A similar condition may occur after compression of the upper abdomen. *Treatment* includes the Fowler position, external heat, and other measures to revive the patient from shock; with rest, guarded stimulation and, later, evaporating lotions, and collyria.

Concussion of the Chest.—This condition results from a violent blow or fall, often without bruising or laceration of tissues; the blow is usually

Fig. 678.—Traumatic cyanosis from severe crushing injury of the chest. The head, neck, and upper chest are cyanotic and of a deep purple color, the conjunctivæ are red from hemorrhagic effusion.

received over the sternum or precordium (*solar-plexus blow*). The symptoms appear immediately, and vary from pallor, vertigo, transient fall of blood-pressure, shock, collapse, loss of surface temperature, very weak, slow, intermittent pulse; superficial, rapid, and irregular respirations, and unconsciousness; to immediate death. The effect is probably produced chiefly through the stimulus of the vagus, or depression of the conductor fibers of the heart or sympathetic.

If the patient does not die at once, there usually is rapid recovery. Prolonged or recurrent symptoms would indicate complicating visceral injury.

Treatment.—The patient should at once be put in the horizontal or the head-dependent position, with rest, warmth, and the general treatment of shock. Artificial respiration may be required, and intravenous or intracardiac injections of adrenalin if the heart fails.

Burns of the chest wall are frequently observed in children, from the ignition of clothing or from the spilling of coffee or other hot liquids; and in the insane or intoxicated, from contact with stoves and other hot substances.

Treatment is similar to that given for burns in general. Secondary contractions may bind the head and neck toward the chest, or the arm to the side, and necessitate extensive plastic operations.

Wounds of the Chest Wall.— 1. *Non-penetrating wounds* frequently involve the chest wall. They include incised, stab, and lacerating wounds, and, as a rule, are not serious unless followed by extensive suppuration or erysipelas.

2. *Open Wounds of the Chest Wall.*—Punctured, stab, and gunshot wounds without a free opening into the chest cavity, and without infection or serious hemorrhage, rarely produce serious symptoms.

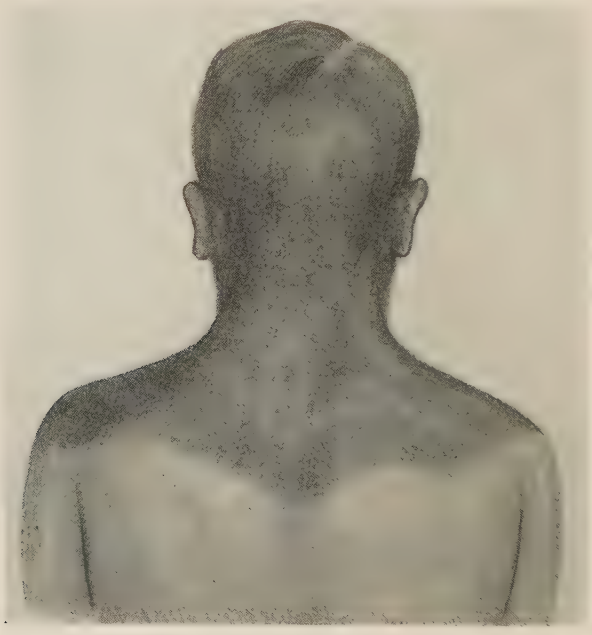


Fig. 679.—Traumatic cyanosis, posterior view.

3. *Contour Wounds.*—The missile strikes the ribs at a tangent and is deflected for a considerable distance around the outer surface of the bony wall of the chest. The relative positions of the bullet and the wound of entrance may erroneously suggest that the chest has been traversed. These wounds are unusual, and it is improbable that a ball ever entirely encircles the chest in the loose connective tissue.

4. *Tunnel wounds* may carry infection to the deeper layers of the chest wall from a considerable distance, as in the case of a man who, sliding off a hay mow, alighted on the end of a pitch-fork handle, which traversed his scrotum and passed between the layers of the anterior abdominal wall to a position under the right mammary gland. A submammary abscess later followed, from which a piece of the trousers was extracted.

Physiologic Changes in Open Pneumothorax.—With an open wound through the chest wall the effect upon the lung depends upon the size of the opening and the mobility of the mediastinal partition. If the opening is smaller in area than that of the trachea, on inhalation a part of the air will enter the thorax through the wound and the greater part through the trachea. The lung therefore expands, although incompletely, with every inspiratory movement. On expiration air may be driven from the opposite lung through the bronchi to the injured side, not sufficient, however, to prevent exhalation. Therefore there is a partial collapse of the affected lung on exhalation, as well as a partial expansion on inhalation. If the wound opening is large, the normal negative pressure (−7 mm. of mercury in the pleura) is replaced by the atmospheric pressure, which not only produces collapse of the lung, but pushes the mediastinum and the attached heart and great vessels toward the opposite side, reducing the capacity of the residual lung. Some distention of the collapsed lung from air entering from the other lung may occur on exhalation. In the dyspnea that follows, the respiratory movement causes oscillations in the mediastinum and the increasing shock that results from a "*sucking*" *wound*. Such a wound should be occluded or closed. If both pleural cavities are open, and the area of the wound openings admitting air to the chest is greater than the area of the trachea, both lungs will collapse, apnea follow, and the patient will die unless measures are taken to secure inflation of the lungs. The wound should immediately be closed by plugging or suture, and the air aspirated from the pleural cavities.

Mediastinal Flutter.—If the area of the opening in the chest wall is larger than the area of opening of the glottis or trachea, the normal negative pressure within the thorax on inspiration and the positive pressure on expiration cannot occur. Rather, on inspiration the mediastinum curves away, while on expiration it bulges toward the open side of the chest. The lung on the side of the opening although largely collapsed, partially expands with expiration and collapses with inspiration, preventing sufficient respiratory interchange of gases, and, at times, causing the rapid development of serious symptoms.

If the mediastinum has been more or less fixed by preceding inflammation, these symptoms do not occur. As shown by Murphy, the displacement and oscillation of the heart in mediastinal flutter are less important than the loss of gas interchange. In an emergency, the condition may be relieved by turning the patient on the open side, pulling the exposed lung into the opening in the thoracic wall, or closing or plugging the opening.

Expansion of the lung is maintained not only by atmospheric pressure, but, in a degree, by molecular adhesion between the two moist pleural surfaces, as shown by Macewen. This is one reason why a lung may not entirely collapse when the chest is open.

A right is more serious than a left pneumothorax, because the right lung is larger and the atmospheric pressure on the thin wall of the aorta and vena cava may prevent the normal aspiration of blood into the chest. In animals, such as dogs, with a thin fragile mediastinum, the danger of pneumothorax is greater than in man and other animals with a stronger partition.

Differential-pressure Devices.—To facilitate respiration with the chest widely open a number of devices have been suggested. The old apparatus of

Fell and O'Dwyer, using bellows for forced artificial respiration in cases of opiate poisoning and asphyxia, was adopted by Northrup in 1896, and modified and improved by Matas in 1902. A somewhat similar device with bellows was used by Tuffier and Hallion in 1895, and by Doyen in 1897. The earlier developmental forms have been succeeded by improved and more practical forms of apparatus. For a unilateral thoracotomy they are rarely necessary.

1. *Positive Pressure.*—A plus pressure of 7 mm. of mercury is maintained in the lung by the use of: (a) Air-tight helmet-like box (Brauer, Murphy) which encases the head, and through which there is a constant flow of air and, if necessary, an anesthetic under pressure. (b) Air-tight mask strapped over the mouth and nose, as used by Tiegel, Henle, and others (1908). (c) Intratracheal insufflation of Meltzer and Auer uses pressure through a catheter introduced in the trachea.

2. *Negative Pressure.—Sauerbruch's cabinet:* At the suggestion of Mikulicz, Sauerbruch (1904) devised a small pneumatic operating-room, in which operations could be done upon the chest at a pressure 7 mm. below that of the external air. The patient's head protrudes through a window in the cabinet, the neck being surrounded by an air-tight soft rubber collar. As when the air is pumped from the room, the negative pressure upon the abdomen and legs may cause a distention of the stomach and intestines with air, and a dilatation of the vessels; the lower half of the body is encased in a pneumatic rubber suit which communicates with the external air.

Disadvantages in the Use of Differential-pressure Apparatus.—1. *Vomiting during anesthesia* with a mask or helmet. There is danger of aspiration of vomitus and the possible necessity of removing the mask or helmet, with fall of pressure.

2. *Acute dilatation of the stomach* from the entrance of air through the esophagus may become very marked or even fatal. It occurs in the use of a negative-pressure cabinet, or in the use of a positive-pressure helmet or mask, but does not occur with tube insufflation. It may be combated by the use of pneumatic trousers inflated with air at a higher pressure than that entering the lung, or by a compress pad, or weight on the abdomen.

3. *Interruption of differential pressure* may be followed by collapse of the lung and secondary alarming symptoms, which are to be treated by plugging the opening with wet gauze, pulling the lung up into the opening, or turning the patient so that the wound is dependent.

4. *Excessive pressure* adds resistance to the circulation of blood in the lung, and increases the work of the right heart. If the difference of pressure is great, or the operation very prolonged, the patient may suddenly die of cardiac exhaustion.

Penetrating wounds of the chest include injuries to important blood-vessels, the diaphragm, thoracic duct, lung, pericardium, heart, or great vessels. *Hemorrhage* from wounds of the great vessel usually is immediately fatal; from the heart, especially the ventricles, the hemorrhage may not be rapid enough to cause immediate death. From the intercostals or internal mammary arteries the bleeding is slower, but may be continuous from the movement and aspirating influence of the chest, so that fatal hemorrhage has occurred from the division of an intercostal artery. Intense shock may be present in injury of the chest

wall without serious injury to the viscera. Hemorrhage from wounds of the lung, except those near the hilum, usually is not severe enough to cause death.

Wounds of War.—*Bayonet wounds* penetrating near the midline, as a rule, are immediately fatal; yet the bayonet often is deflected by the sternum or ribs, with extensive division and laceration of muscle and free hemorrhage, but without penetration of the chest wall. Secondary sepsis is common.

Bullet wounds through the base of the neck or through the great vessels of the chest usually cause instant death. Recovery may occur from bullet wounds of the heart, especially after operative closure.

Perforating wounds through the lungs frequently are followed by little disability and early recovery. After penetrating wounds, the bullet may be encapsulated in the lung, pleura, or chest wall, without secondary symptoms. If the bullet carries bits of clothing or other infectious material, a secondary abscess or empyema will follow.

Grenade wounds are usually multiple, the fragments, as a rule, being smaller and having lower velocity than those of high explosive shells.

Shrapnel Wounds.—The bullets from shrapnel have a low velocity, often lodge in the chest wall, and produce rather superficial, infected, lacerated wounds. The pain from these wounds of war is often slight.

Complications of thoracic injury include effusion of air, blood, serum, or pus into the pleural cavity; also pneumonia, exacerbation of pre-existing tuberculosis, albuminuria, glycosuria.

Prolapse of the lung into the subcutaneous tissues may occur with or without fracture of the rib, and in rare instances may follow coughing or strong expiratory efforts (*hernia of the lung*), as from blowing wind-instruments; without subjective symptoms.

Prognosis.—While any wound of the chest is serious, perforating wounds of the chest are dangerous from the initial shock, the primary or secondary hemorrhage, the effect upon the lungs, heart, and great vessels, and the secondary septic complications. A small punctured, stab or bullet wound, or one made obliquely with valvular closure may not admit air to the pleural cavity and, if uncomplicated, may be followed by rapid recovery, as in the soldiers who return to duty a week after a bullet has passed through the lungs. In the elderly the prognosis is always grave. Death may be immediate from shock or hemorrhage or occur from secondary complications, as pneumonia, empyema, or sepsis, or the wound may leave more or less chronic disability.

General treatment of open wounds of the chest includes the arrest of hemorrhage, removal of foreign bodies, disinfection and possible closure of the wound and prophylaxis against tetanus.

1. *Shock* is to be treated by absolute rest, the patient being wrapped in blankets, surrounded by hot-water bottles, and placed on his back or on the wounded side with the head lowered. The pain, cough, and restlessness should be controlled by hypodermic injections of morphin. A pint of coffee containing 2 ounces of glucose and 2 drams of capsicum may be given by rectum, and salt solution given subcutaneously. On reaction, to facilitate respiration and reduce hemorrhage, the Fowler position should be used.

2. *Hemorrhage* from large vessels should immediately be controlled by suture or ligature. The chief sources of hemorrhage are the long thoracic, the internal mammary, and the intercostal arteries. For an intercostal artery *Desault's method* may succeed. The center of a square of gauze is pushed between the ribs, and then packed with strips of gauze. By traction, the pad of gauze is pulled against the ribs, compressing the vessels from within. If this fails, the rib should be resected and the vessel tied under local anesthesia. Bleeding from the lung may be arrested by the collapse produced by hematothorax or pneumothorax. To favor the collapse of the lung, air may be injected into the pleural cavity. Packing against the open lung or in the pleural cavity usually is ineffective, and if, with an open wound, the collapsed lung is found to be bleeding, it should be treated by suture or ligation.

3. In certain cases of *pneumothorax* or *hematothorax* with marked pressure-symptoms, aspiration may be necessary. Open drainage of the pleura for aseptic pneumothorax or hematothorax should not be used, on account of the secondary infection and collapse of the lung that follow. Blood is quite rapidly absorbed from the pleural cavity, and the process may be aided by aspiration several days after the injury.

4. *Missiles* often become encapsulated and harmless, and may be left without removal, as in the case of Colonel Roosevelt. Clothing, organic substances, and the like cause infection and require removal.

5. *Sucking wounds* of the chest and valvular wounds with extensive pneumothorax from aspirated air should immediately be plugged by wet antiseptic gauze covered by an impermeable pad, or closed by suture.

6. *Secondary Infection.*—As soon as the patient's condition permits, the wound should be asepticized by mechanical débridement and by antiseptics, accessible foreign bodies removed, and the wound closed. Where infection is likely, the pleural wound may be closed, and the external wound left open or partially closed with drainage, or treated for a possible delayed secondary closure. If infection follows, free drainage should be instituted, with ample incisions if there is spreading infection between the muscular planes. Pyothorax is to be treated as elsewhere described.

Infections of the Chest Wall.—**Boils and Carbuncles:** The thick hairy skin of the back with its many sebaceous glands is a usual seat for acne and pustules; furuncles and carbuncles are common, although less frequent here than on the back of the neck. Carbuncles occur especially after middle life, in men, in the diabetic and nephritic, and involve the skin, muscle, fascia, and even the spinous processes of the spine and scapula, and may cause very serious or even fatal sepsis.

Treatment follows the plan given on page 465.

Suppurations of the Chest Wall.—Spreading infections of the chest wall with suppuration are serious but not very common. As a rule, they originate from infection disseminated from the axillary or subpectoral lymph-nodes, the suppuration spreading into the axilla, and over the anterior chest above or below the fascia of the pectoralis major. Extensive necrosis of muscle may occur. Infection also follows traumatism, the entrance of foreign bodies, missiles, needle-points, or bits of clothing, and as part of a general pyemia from typhoid

fever or other general infection; or secondary to purulent osteitis of the ribs or sternum. The pus spreads beneath the breast, pectorals or scapulæ; it tends to rupture externally, and rarely it perforates the pleura or lung and is expectorated, the patient often dying from disseminated sepsis.

Axillary infections are favored by the moisture and the number of hair-follicles of the armpit. Pustulation and furunculosis with single or multiple points of suppuration are common. The skin being thin, induration is limited. Pointing and evacuation occur early, with spreading of the infection and formation of new lesions. The process may continue for weeks.

Treatment.—With the onset of irritation, itching, or pain, the skin should be cleansed several times daily, and 1 : 4000 sublimate alcohol applied, followed by a dusting-powder of boric acid, or, if there is evidence of infection of the deeper layers of the skin, by the application of 2 per cent. yellow oxid-of-mercury ointment. Pustules and abscesses should be evacuated, the surrounding skin frequently disinfected with alcoholic lotion, and the antiseptic ointment continued to prevent reinfection.

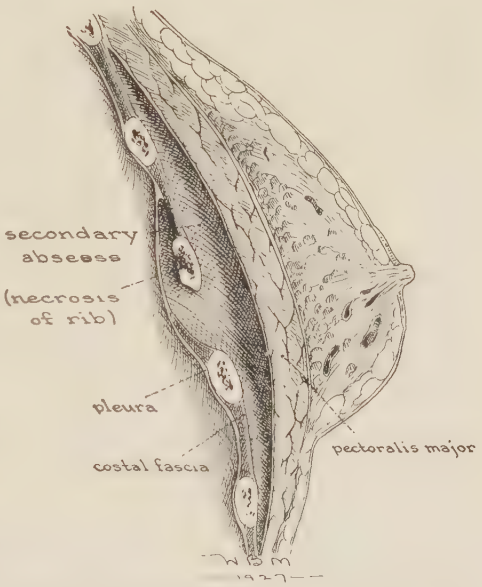


Fig. 680.—Subpectoral retromammary abscess from necrosis of a rib.

Axillary abscess may be deep, from the infection of the axillary lymph-nodes which become enlarged, tender, liquefy, and finally coalesce into an abscess. The infection may originate in the hand, arm, mammary gland, or thoracic wall. The depth of the infection may prevent the early appearance of characteristic changes in the skin. Rarely the pus may spread along the axillary vessels to the neck or, more frequently, gradually penetrate through the axillary fascia to the skin. A vertical incision is made in the axillary fossa against the thoracic wall, the pus localized and evacuated by Hilton's method, a tube or gauze drain inserted, and the arm immobilized by bandaging.

Subpectoral abscess occurs between the pectoralis minor and chest wall or between the pectoralis major and minor, from infection of the subclavian lymph-nodes lying on the anterior surface of the pectoralis minor or coracoclavicular (clavipectoral) fascia, and draining the extensor surfaces of the fingers and forearm. It may also develop as an extension from the axilla, as a part of a general metastatic infection in pyemia, or from infections of the thoracic wall and cavity, especially tuberculosis or empyema. There is a tender swelling below the medial part of the clavicle; the abscess tends to point at the lower border of the pectoralis major, or penetrates the pleura through an intercostal space.

Treatment.—Incision along the lower border of the pectoralis major, and free drainage. The mortality is about 50 per cent.

Subscapular abscess is rare, may result from infection of the scapula or shoulder-joint, the pus forming between the serratus anterior and the posterior thoracic wall. The pus, limited anteriorly by the attachment of the serratus anterior to the thorax and medially by the attachment to the scapula, points beneath the trapezius or at the angle of the scapula.

The *treatment* is incision at the lower angle of the scapula, with drainage.

Suprascapular abscess is unusual, it may follow an injury or hematoma of the supraspinatus, or result from tuberculosis of the scapula.

Diagnosis of suppuration of the deeper layers of the thoracic wall may be difficult in the early stages. The condition usually starts with chill, fever, tenderness, and pain on movement and respiration, and may be mistaken for a rheumatic affection or acute pleurisy. Edema of the skin and deep fluctuation appear later.

Early treatment includes free incision, with adequate dependent drainage and general supportive and antitoxic treatment.

Suppurations of the chest wall, the result of extension from within the thoracic cavity (such as *empyema necessitatis*, peripleuritic abscess, perforating abscesses of the lung), should be differentiated from those originating in the chest wall. Especially important is the differentiation of non-inflammatory lesions from abscess. A thoracic aneurysm perforating the chest wall forms a progressive, painful, subcutaneous enlargement. The characteristic expansile pulsation and bruit is not always detected. Incision has, in a number of instances, been followed by fatal hemorrhage. In case of doubt, exploratory aspiration by a fine hypodermic needle should first be tried.

Hernia of the lung is usually tympanitic, increases in size on forced expiration, and is reducible by pressure with crepitation.

A *cavernous angioma* is dull on percussion, and may be reducible like a hernia of the lung.

Suppurative osteitis and **osteomyelitis of the ribs and sternum** occur as sequelæ of typhoid fever; more often these infections are due to the staphylococcus. The treatment is the early drilling of the infected bone, as elsewhere described, associated with the subcutaneous use of staphylococcus vaccine and sodium cacodylate. If the process continues, free incision, removal of the dead bone, and drainage may be necessary.

Tuberculosis or **cold abscesses** of the chest wall chiefly originate in the spine, ribs, or sternum, and the pus—spreading widely along the intermuscular planes—may form an enormous abscess. Evacuation by aspiration or incision, and, in some cases, the excision of the affected area of bone or walls of the abscess may be required. As in other tuberculous abscesses, open drainage is to be avoided.

Tuberculosis of the Bones of the Chest Wall.—Seven per cent. of the cases of tuberculosis of bone involve the sternum, ribs, or clavicle. The process begins centrally, gradually spreads to the cortex and periosteum, which becomes thickened, and an abscess forms which erodes its way to the surface of the skin, with the formation of one or more chronic fistulous tracts. A single rib may be

involved with many sinuses or, less often, nearly all the ribs may be affected. Rather rarely the tuberculosis begins in the periosteum. If the focus is internal, a parapleuritic abscess with separation of the pleura from the chest wall forms. The costal cartilages are often involved and the process may continue for many years with chronic, rather indolent discharging sinuses. Pulmonary infection is usually associated.

Prognosis.—Tuberculosis of the ribs, sternum, and costal cartilages is often difficult to control, but seldom causes death. The associated pulmonary tuberculosis, however, may be fatal.

Treatment consists of the removal of necrotic bone and costal cartilage, the disinfection and excision of fistulous tracts, and closure. As operation without dissemination of infection and recurrence is difficult, the cautious use of the zinc-chlorid and methylene-blue method of excision is advised. In the topical treatment of sinuses, the application of liquefied phenol followed by alcohol, and the filling of the sinus with Beck's paste or a 50 per cent. red iodid-of-bismuth paste is of value. Actinic or Roentgen treatment, and attention to nutrition and rest, as in all cases of tuberculosis, should not be neglected.

Syphilis of the Chest Wall.—Secondary and tertiary lesions of the skin of the chest and the mammary gland are common. Occasionally tertiary lesions involve the sternum or ribs, giving symptoms that closely resemble tuberculous osteitis, except that the syphilitic process usually develops first in the periosteum, forming a spindle-shaped tumor with purulent coagulation necrosis, and formation of sequestra. Gummatous tumors also occur on the sternum. The pus is more tenacious and homogeneous than the thin caseous flocculent pus of tuberculosis. Syphilitic and tuberculous lesions may coexist in the same patient.

Diagnosis is made from the history, the Wassermann test, the examination of tissue, the injection of animals, and the influence of treatment.

Treatment.—Necrotic bone should be removed, sinus tracts kept clean and filled with bismuth paste, arsenic given intravenously; and in resistant cases 6 to 16 gm. of iodid daily, give results when smaller doses are ineffective.

Actinomycosis of thoracic wall may spread from infections of the mouth (carious teeth), larynx or lung, or follow the inhalation of chaff from a threshing machine. Infiltration and abscess formation occurs in the lung, and fistulous tracts form through the pleura and chest wall, with progressive brawny infiltration and the formation of multiple abscesses and sinuses of the skin.

The *diagnosis* is made by finding the characteristic fungus in the discharge and tissue.

The *prognosis* is unfavorable if the lungs and pharynx have been involved.

Treatment consists of intermittent use of massive doses of iodid, roentgenotherapy, and the drainage and local disinfection of abscesses and sinuses.

Intercostal neuralgia occurs in women during middle life, and is characterized by shooting, darting, neuralgic pains, radiating from the back along the course of one or more intercostal nerves, that may be referred to the upper abdomen and produce symptoms mistaken for biliary or renal colic, or acute appendicitis. The early pains of herpes zoster, the lightning pains of tabes, and the pains from the pressure of spinal neoplasms or other conditions involving the nerve-roots or nerve-trunks should carefully be differentiated. The pain may interfere with

movement and respiration. Treatment includes the removal of underlying foci of infection, free elimination, the use of aconite, gelsemium, salicylates, iodids, or similar drugs. If relief does not follow, the intercostal nerves may be blocked by injecting a 3 per cent. solution of phenol or 85 per cent. ethyl alcohol.

In **spondylolisthesis** or in destructive disease of the spine, the ribs may overlap or rest upon the iliac crests, with impingment and irritation of the intercostal nerves. Relief in these cases may be obtained by nerve-blocking or by resecting segments of one or more ribs at the points of pressure.

Entozoa.—*Trichina* frequently involve the intercostal muscles; the *cysticercus*, the pectoralis major and minor and, rarely, the trapezius; *echinococcus* cysts develop in the bones under the pectoral muscles, or subcutaneously.

Hydatid cysts should be injected with tincture of iodin, formalin or other disinfectant, excised, or evacuated and drained. They may be mistaken for lipomata, cystic tumors, or abscesses.

Benign Tumors.—Cysts: *Sebaceous tumors* or *atheromas* are common in adults, on the back or front of the chest. They are tense, round or oval, and the minute outlet of the sebaceous duct is found directly over the growth. In middle life they often become inflamed and suppurate. They should be excised.

Dermoid cysts are rather rare and are found on the front or back of the chest in the midline, the chief sites being the upper part of the sternum near the junction of the manubrium and gladiolus, and over the spinous processes of the dorsal vertebræ. The sternum may be fissured, or the spine rudimentary or bifid under the growth.

The *treatment* is enucleation and closure.

Ephelides and *pigmented moles* are very common. Crops of flat verrucæ often develop after middle life. *Nævi pilosi* (flat or pigmented hairy moles) may cover a considerable area of the skin and be very disfiguring. These moles may be removed by caustics, fulguration, radium, Roentgen ray, or scalpel. Keloids are not uncommon, often recur after excision or after caustic or electric treatment, but sometimes disappear spontaneously, or after radiation.

Lipomata are the most common of the larger tumors about the shoulder, base of the neck, the upper anterior chest, and scapula. They are encapsulated, lobular, soft, usually subcutaneous, sometimes pedunculated (*lipoma pendulum*) and rarely intermuscular—beneath the pectorals—or submammary. Retromammary growths may cause atrophy of the overlying breast, yet simulate a mammary hypertrophy.

Treatment is excision, which may be done under local or gas-oxygen anesthesia. With careful hemostasis drainage is not required.

Fibromata are firm, not lobulated, round and encapsulated, usually submuscular, and rarely over a few centimeters in diameter.

Fibroneuromata (*myxoneuromata, v. Recklinghausen's disease*) develop in the nerve-sheaths, are usually subcutaneous, multiple, and often associated with large or small masses of fibroma molluscum. Hundreds or thousands of growths may be present and the entire body be involved, new-growths may continue to appear and sarcoma supervene. When painful or disfiguring they should be removed.

Hemangiomata may be *telangiectatic* or *cavernous*, and occur on the chest

next in frequency to the head and face. They usually are slightly elevated, and bright or dark red in color.

Cavernous angiomata may be large, are frequently found at birth, and may be treated by radium, electric coagulation, or the injection of a 30 per cent. solution of quinin and urea.

Lymphangiomata usually develop from the lymphatic vessels of the axilla, extend beneath the pectoral muscles, and may form large cystic tumors that occasionally extend into the mediastinum.

Treatment.—Radical excision; for the larger growths a two-stage operation may be desirable.

Enchondromata grow from the sternum or ribs and often show sarcomatous admixture, recurring after excision and giving rise to metastasis. About 2 per

Fig. 681.—Metastatic sarcoma of the left anterior thoracic wall, associated edema of the left side of the face and neck. (Dr. G. Mason Astley.)

cent. of chondromata involve the ribs, and may follow a fracture; a smaller proportion affects the sternum.

Prognosis.—Chondromata tend to invade the pleura and mediastinum, and press on the thoracic organs, making the prognosis unfavorable.

Treatment should be early and free excision, with removal of adjacent soft tissues to prevent recurrence.

Malignant Growths.—**Melanotic sarcoma** occasionally develops from a pigmented mole. Obviously it is impossible to remove every pigmented mole, and rapid sarcomatous dissemination has followed excision. *Osteo-* and *chondrosarcoma* grow from the sternum and ribs; the sarcoma develops more frequently from the sternum, may be very vascular and pulsate, suggesting a perforating thoracic aneurysm. Chondrosarcomata usually arise from the ribs near the costochondral junction, and may follow a fracture or bruise of the bone. They

are relatively painless, invade the chest, and reach great dimensions. Central sarcoma of the ribs produces a fusiform swelling, is more painful, by pressure causing intercostal neuralgia.

Prognosis. Sarcoma and chondrosarcoma tend to progress rapidly to a fatal issue, and at operation are usually found much more extensive than the external examination would indicate.

Treatment.—A malignant growth should be treated by early radical resection of the chest wall. The defect may be closed by sliding adjacent skin, forming a skin-flap, or transplanting the opposite mammary gland on a pedicle over the defect. Palliative treatment in recurrent and advanced conditions is by radium or roentgenotherapy.

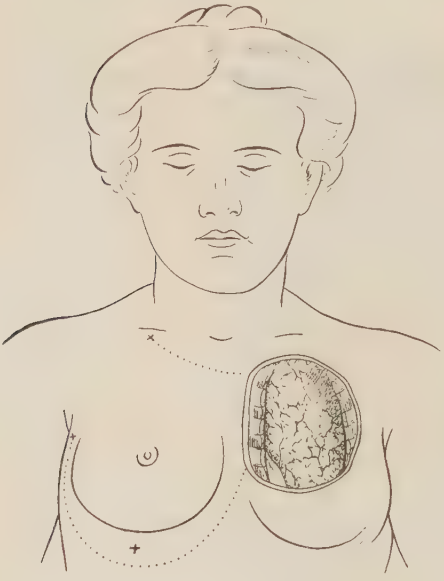


Fig. 682.—Plastic closure of a defect in the thoracic wall after resection for secondary carcinomatous ulcer, by transplantation of the opposite breast. Dotted lines indicate skin incisions.

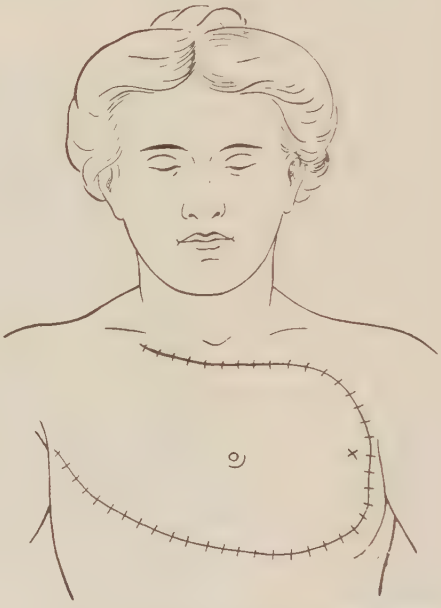


Fig. 683.—Transplantation of the right breast to cover defect in left thoracic wall.

Primary Sarcoma of the Sternum.—The following varieties occur: (1) Osteosarcoma; (2) chondrosarcoma; (3) myxosarcoma; (4) angiosarcoma; (5) vascular pulsating sarcoma.

Secondary sarcoma develops from the mediastinal lymph-nodes (lymphosarcoma) or from a sarcoma of the thymus.

Sarcoma of the ribs occurs as a (1) central growth, or a (2) surface growth near the junction of the costal cartilage. The rate of growth is usually more rapid than with a chondroma.

The mortality of resection of the sternum for sarcoma is from 20 to 50 per cent., and permanent cures are almost unknown; for resection of ribs for sarcoma about 26 per cent., with a prognosis slightly better than for the sternum.

Sarcoma also originates from the scapula or clavicle. Sarcomata of the soft

tissues of the chest: the intermuscular planes, muscles, aponeurosis, are rather rare, may grow to great size, tend to undergo central degeneration and necrosis, and give an unfavorable prognosis.

Primary carcinoma of the chest wall occurs only as epithelioma of the skin. In the young, epithelioma is found developing in extensive scars following burns of the chest wall. Epithelioma of the skin usually is of slow growth, lymphatic invasion is rather late, and the treatment should be early radical excision.

Fig. 684.—Transplanted breast covering defect in the left thoracic wall. The patient suffered from an exceedingly painful Roentgen-ray and carcinomatous ulcer which was sterilized by zinc chlorid and the entire thickness of the involved thoracic wall resected. The operation gave the patient relief from the pain for six years.

Secondary carcinoma of the chest wall occurs from direct invasion of the soft tissues, ribs, or sternum from carcinoma of the breast, or as a metastatic condition particularly in the bodies of vertebræ, with cord or root symptoms or, in the clavicle, with pathologic fracture.

Treatment usually is palliative, with local support and protection, and the use of hypnotics and sedatives for a relief from the pain.

CHAPTER XLIII

THE MAMMARY GLAND

Congenital Anomalies.—Agenesia: Absence of the mammary gland (*amazia* or *amastia*) is rare, as is also absence of the nipple (*athelia*), and usually is associated with defects in the development of the reproductive organs. **Hypoplasia,** shown by *micromastia* or *micromazia*, an imperfectly developed or infantile breast, is not infrequent.

Polymastia (*polymazia, multiple breasts*) and especially **polythelia** (*multiple nipples*) are not uncommon. The supernumerary nipples or glands are usually

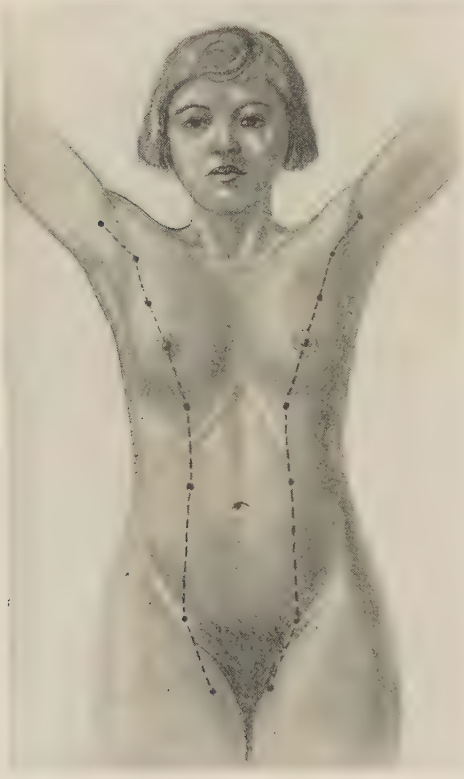


Fig. 685.—The milk-line, lines along which accessory nipples and mammary glands are found.

Fig. 686.—Hyperplasia of the mammary gland.

rudimentary, and are often mistaken for slightly pigmented moles. They occur along the *milk-line*, running from the shoulder through the nipple to the pubis, corresponding to the location of mammary glands in lower animals, and on the shoulder, back, over the deltoid, outer surface of the thigh, or below the trochanter. Usually there is only a single supernumerary nipple or gland, a few

centimeters below the normal gland. During pregnancy accessory mammæ may become swollen and painful, but seldom are sufficiently well developed to secrete milk.

Gynecomastia refers to a hypertrophied gland of the feminine type in the male. Usually unilateral, it rarely secretes milk, although a negro shown to classes at the University of Maryland had served as a wet nurse.

Hypertrophy of the female breast develops at puberty, during pregnancy or lactation. *Massive hypertrophy of the breast*, involving both breasts, occurs in young women at puberty or the first pregnancy.

Varieties.—(1) Fibro-epithelial. (2) Adipose, the fatty form, is rare. The breast in the course of a few months may become so enormous as to rest upon the thighs, interfere with work, and cause emaciation. In Durscon's case the left breast weighed 64 pounds, right 40. In Porter's case the weights were 43 and 17 pounds.

Pathology.—The condition is not a true hypertrophy, but a great overgrowth of fibroconnective, myxomatous tissue, or possibly fat. The consistence is soft and somewhat nodular, except in the fatty type.

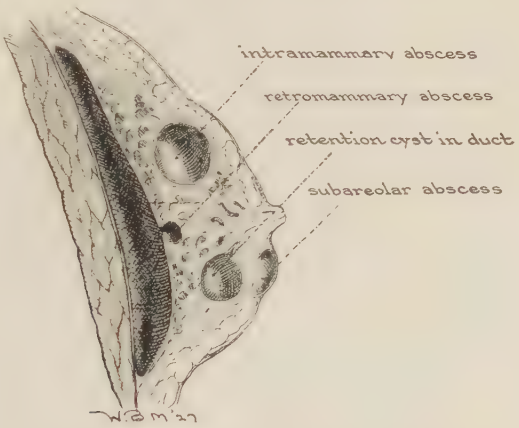


Fig. 687.—Varieties of mammary abscess, premammary, intramammary, retromammary. The development of a retromammary abscess from a deep lying intramammary abscess is shown.

Diagnosis.—Hypertrophy may be simulated by a retromammary lipoma, or an associated fibrosarcoma.

Treatment.—Iodids, thyroid extract, and radiation may be tried in conjunction with a supporting bandage, or strong brassiere. Amputation or resection of the breast is required for the extreme type. For enlargement following pregnancy, operation should be delayed until the degree of normal involution is evident.

Traumatism.—Bruises, and incised or lacerated wounds of the breast usually heal rapidly. Division of ducts, or their occlusion by effused blood or inflammatory products, favors the development of retention cysts.

Mammillitis.—The nipple is subject to excoriations, cracks, and fissures during lactation. Through these openings bacteria may invade the breast and produce mammary abscess. During pregnancy the nipple should be prepared

by alcoholic or astringent lotions. For the lactating gland scrupulous cleanliness should be observed. Before and after each nursing the nipple should be washed with a saturated solution of boric acid, or a 2 per cent. solution of aluminum acetate. Fissures should be disinfected with a 4 per cent. solution of nitrate of silver, rarely repeated oftener than once in four days, and varnished daily with compound tincture of benzoin. It may be necessary to use nipple-shields or protectors, and to remove the milk by massage or a breast-pump. Thrush, syphilis, and tuberculosis may be conveyed to the nipple through nursing. Eczema with much crusting about the nipple is usually due to lack of cleanliness or irritating soaps and lotions. A paste of bismuth and castor oil, a drying powder such as thymol iodid, cleanliness with borax or boric acid solution, and the avoidance of soap usually give relief.

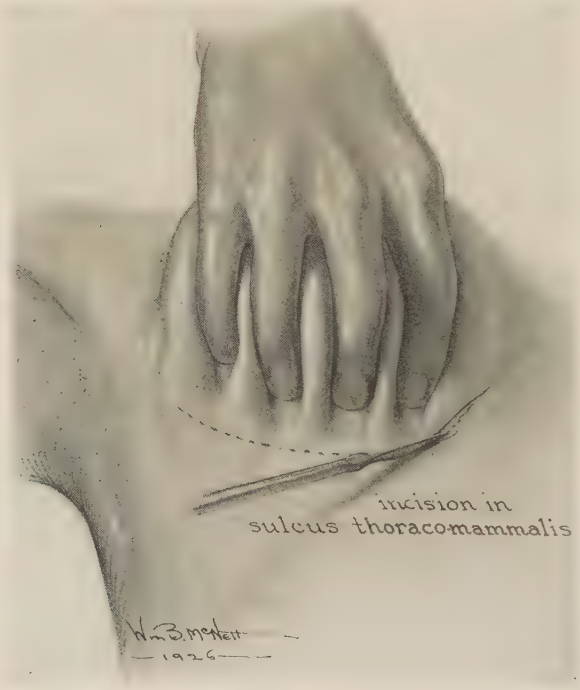


Fig. 688.—Thomas-Warren incision, useful in opening mammary abscesses and in the removal of the benign tumors of the breast without disfiguring scar.

Mastitis neonatorum appears four to six days after birth, especially in male babies. The skin of the breast becomes swollen, reddened, and a clear milk-like fluid can be squeezed from the nipple. Suppuration may be excited by the practice of ignorant lay nurses of pulling upon the nipple to break the "nipple-string." Boric lotion followed by the application of a 1 per cent. yellow oxid-of-mercury ointment should be used, with incision and drainage as soon as suppuration occurs.

Mastitis Adolescentum.—At puberty a disk-like induration under the areola often develops, suggesting a neoplasm. In boys this is usually painless and gradually passes away, in girls the gland may become tense, hard, elastic.

and contain circumscribed small nodules. Aching pain, sensitiveness to pressure, and pigmentation of the areola may be associated. The condition either subsides in a few weeks, or is more persistent, with enlargement of the lymph-nodes of the axilla. Suppuration is rare. A painful swelling of the breast often occurs at the time of menstruation, and occasionally is associated with discharge of a little clear, turbid, or even bloody fluid from the nipple.

Treatment is the daily application of a 3 to 5 per cent. yellow oxid-of-mercury ointment in the more marked cases, with elastic support and protection by a well-fitting bandage or brassiere, and attention to the general nutrition of the patient.

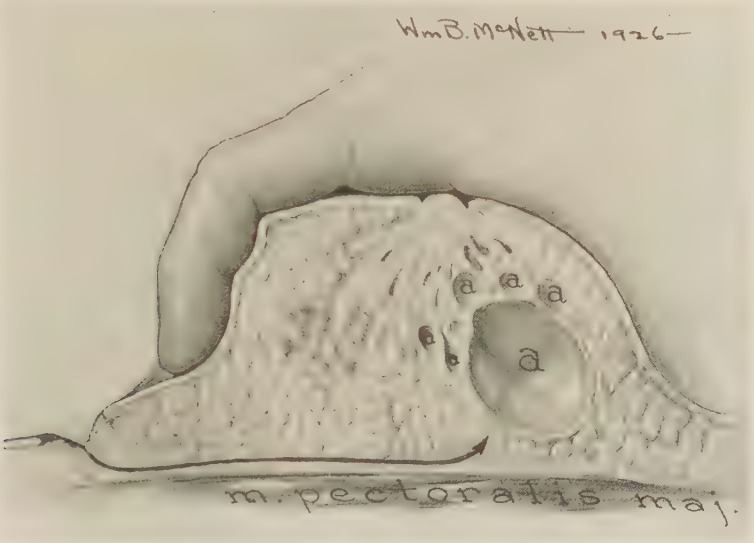


Fig. 689.—Mammary gland, cross-section, illustrating retromammary approach for mammary abscess.

Mastitis Puerperalis.—Inflammation of the mammary gland is especially common during lactation, the bacteria usually entering the breast through an abrasion or fissure of the nipple, produced in nursing.

Acute parenchymatous mastitis (*caked breast*) follows the retention and stagnation of milk in the breast. It occurs through failure, due to the pain of fissured nipples or other cause, to regularly empty the lactating breast.

Symptoms include slight fever, enlargement of individual lobes of the breast, with firmness and tenderness. The skin may be slightly reddened, and the axillary lymph-nodes enlarged.

Treatment.—Prophylactic care of the nipples. Careful massage, with suspension support, pressure, and regular emptying of the breast. Hot moist saturated boric-acid or Epsom-salt compresses. If the child is no longer nursing, saline laxatives, iodid of potassium, and belladonna should be given. Belladonna ointment or plaster may be applied locally.

Acute suppurative mastitis follows acute parenchymatous mastitis or caked breast from the invasion of bacteria along the lymphatics or ducts from

the nipple. The abscess is: (1) Premammary. (2) Intramammary. (3) Post- or retromammary.

1. **Premammary abscesses** are small subcutaneous collections without deep involvement of the gland. They are to be treated by early incision, swabbing with tincture of iodin, and a bismuth-paste dressing. The incision should follow but not cross the areolar border, or it should run on a line radiating from the nipple directly over the abscess.

2. **Intramammary abscess** is characterized by temperature, chill, local pain, throbbing, swelling, tenderness, with redness and edema of the skin. The enlargement is usually limited to one or two lobes of the gland. The axillary lymph-nodes are often swollen and tender. If not opened, the abscess enlarges, approaches the surface, and finally points and discharges through the skin, at

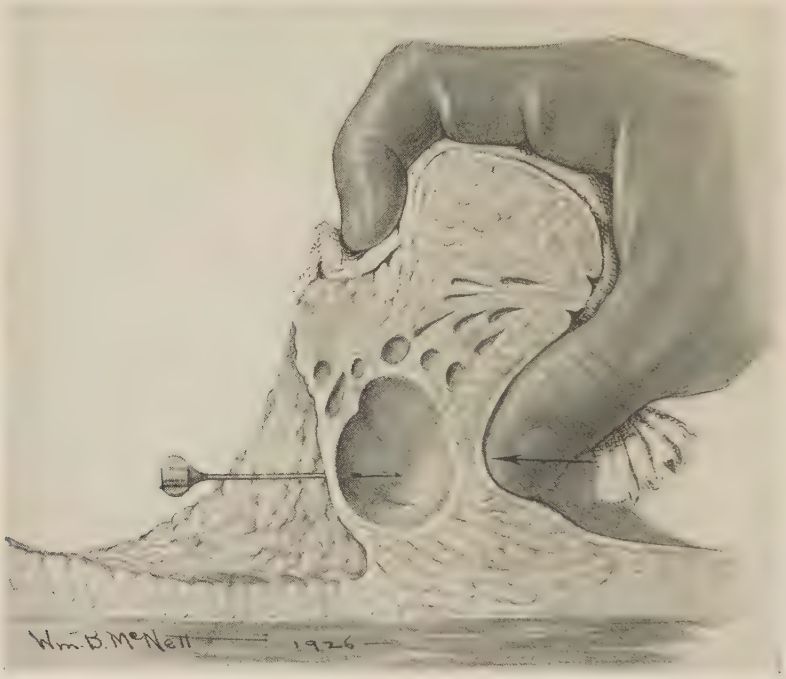


Fig. 690.—The localization of intramammary abscess by needle puncture is rarely necessary.

one or more points. The swelling may block the adjacent and peripheral milk-ducts and acini, so that secondary peripheral stagnation and abscess formation follows improper treatment, one abscess forming after another.

Treatment.—Prophylaxis includes the care of the nipples during pregnancy and lactation, and the treatment of the caked breast. As soon as intramammary suppuration is evident, a free crescentic incision is made about the lateral and lower margin of the gland (thoracicomammary fold). *Thomas-Warren Incision* (Gaillard Thomas, 1882; Warren, 1905): Under nitrous-oxid or ethylene anesthetic the gland is separated from the pectoralis, turned over, and the abscess or abscesses freely opened from the under side by incisions radiating from the nipple to avoid the unnecessary division of the milk-ducts. Tube and gauze

drains are introduced into each cavity, the gland kept from the chest wall by layers of gauze, and moist antiseptic external dressings held by a supporting bandage. This operation gives ample dependent drainage, is rarely followed by secondary abscess formation, and the residual scar is not disfiguring.

3. **Retromammary Abscess.**—The gland is floated from the chest as upon a water bed, by the underlying pus, and there is but little swelling, redness, induration, and pain in the breast proper.

The *treatment* is free drainage by the Thomas-Warren incision.

Through-and-through drains with tubes or gauze should not be employed, as they produce mutilation and favor recurrent abscesses, prolonged invalidism, and multiple operations.

Chronic Mastitis.—Involution Mastitis.—With the involution of the breast, the secreting structure is replaced by fibroconnective tissue and fat. The fibrosis or hyperplasia may involve a lobe (*lobar mastitis*) which becomes enlarged, firm, tender, neuralgic, the condition persisting for months or years, the

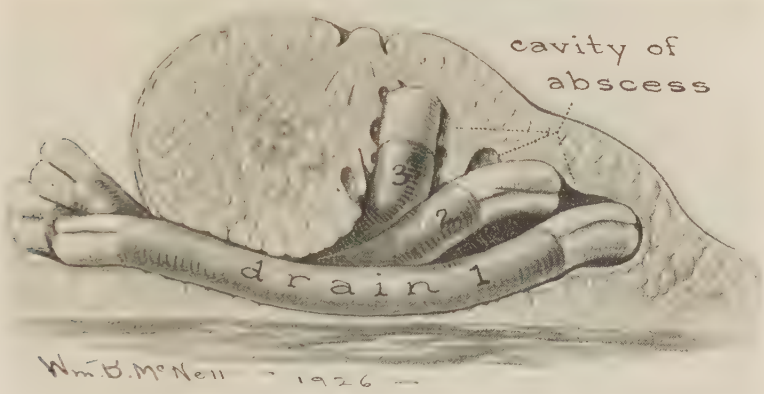


Fig. 691.—Mammary abscesses opened and cigarette-drains introduced.

pain often increasing at the time of menstruation. The condition is common at the time of the menopause, but may follow pregnancy.

Treatment is local support, gentle massage with white or yellow precipitate ointment; the internal use of small doses of iodids or thyroid, and the reassurance of the patient who fears carcinoma.

Chronic diffused lobular (*interstitial*) **mastitis** results from the involution of the breast with fibrosis, the contracting connective tissue making pressure on the ducts. The breast becomes smaller, irregular, lumpy, or cystic. If many cysts form, the condition is termed *Schimmelbusch's disease* or *cystic mastitis*. The cysts are usually multiple, tense, and round, from the size of a pea to that of a marble; the walls are thin, and the contained fluid clear, yellowish or dark brown. If the fluid is aspirated by a hypodermic needle, the cyst usually does not refill. The disease tends to be progressive, new cysts gradually forming so that, if a part of the breast is surgically resected, the residual part later develops cystic change. The condition is not a precancerous lesion, and carcinoma is rarely associated with cystic mastitis.

Diagnosis.—The cysts may be indefinite when pressed against the chest wall with a flat hand, although readily recognized when picked up between the thumb and finger. Although the axillary glands may be enlarged and tender, the skin or underlying tissues are never adherent. Each cystic mass is perfectly round, not nodular or craggy. In case of doubt, an exploratory section should be done, with preparation for immediate radical excision in case carcinoma is found.

Treatment.—If there are but few cysts, these may be emptied by a hypodermic needle and syringe. If the disease is widespread and progressive and the patient very apprehensive of cancer, subcutaneous ablation of the gland is advised.

Tuberculosis of the breast constitutes 1 per cent. of all tuberculous lesions, and 6 per cent. of the benign lesions of the mammary gland. It occurs in women between the ages of twenty and fifty, affecting, as a rule, the right breast and upper outer quadrant. In 60 per cent. the lesion is primary. In 40 per cent. there is an associated tuberculosis of the lungs, ribs, cartilages, or pleura.

Symptoms.—The lesion may develop after an injury. The breast becomes swollen, with discrete or confluent nodules. Areas of softening appear, the skin becomes dusky red and infiltrated, with the formation of sinuses that have soft undermined edges and edematous granulations in which tubercles may be found. The condition is usually confluent from the coalescence of caseating tuberculomas, but occasionally there are nodules disseminated throughout the gland. The pus is thin and cheesy, and the condition is exceedingly chronic, but associated with but little pain.

Diagnosis.—Histologic and microscopic study may be indefinite; animal inoculation is more reliable. The general health often is good. An associated or preceding tuberculosis of the cervical or axillary lymph-nodes may be present. The nipple may be retracted. The induration is less than in carcinoma, the skin not retracted. Caseation is usual. The diagnosis from gumma may be difficult.

Prognosis is favorable if the disease is limited to the skin and mammary gland.

Treatment.—If the disease is not too extensive, disinfection of the sinuses by phenol followed by alcohol, and their injection with red iodid-of-bismuth paste, associated with heliotherapy or radiotherapy, rest and overfeeding should be tried. Injections of tuberculin and the intravenous use of neo-arsphenamin or sodium cacodylate are at times helpful.

If the breast has been largely destroyed or the process is very extensive or resistant, mastectomy is advisable after first packing the sinuses with cotton pledgets impregnated with a saturated solution of chlorid of zinc, to prevent infection of the wound.

Dermatitis papilloma malignans (*Paget's disease of the nipple*—Paget, 1874) precedes or is associated with 1 per cent. of carcinomata of the breast. It usually affects the right breast in women between thirty-five and sixty years of age, and is characterized by sharply outlined areas of superficial ulceration, showing a vivid red surface that exudes a viscid, clear or yellowish, sticky discharge. The edges of the ulcer are slightly elevated and circinate, the

ulcerating surface is finely granular. The area has a superficial parchment-like induration, and the nipple tends to disappear. The condition may persist for years with recession and exacerbation. Pustules and vesicles are absent. The disease resists anti-eczematous and other local applications, but may improve under radiation.

Carcinoma of the underlying breast usually is early associated with Paget's disease.

Treatment is early amputation, in view of the almost inevitable carcinomatous involvement.

Retention and Exudation Cysts.—Cysts of the larger ducts: Small cystic dilatations of ducts under the areola occur in women between twenty-five and forty-five years of age. They are painless, difficult to detect by

Fig. 692.—Paget's disease of the nipple. The nipple has been destroyed. The edges are circinate, the surface is vivid red, with a mucilaginous, clear, or yellowish discharge.

palpation, and characterized by the discharge of a serous, mucous, turbid, or bloody fluid from the nipple at varying intervals. A small lump the size of a pea or bean may be felt under the areola. Pressure is followed by escape of fluid from the nipple, and the disappearance of the lump.

Papillary intraductal growths occur at any age, but usually after the menopause. They are small and of slow growth, usually unilateral and single. One-third are slightly painful, and in one-half the discharge from the nipple is bloody. In 15 per cent. or more of the cases carcinoma (usually of low malignancy) supervenes.

Treatment.—Extirpation. As the tumor may be difficult to locate when empty, a temporary ligature or elastic band should be placed around the nipple to prevent the escape of the contents, and the tumor exposed preferably through

an incision accurately placed in the areolar border. The dilated portion of the duct should be excised and, if there is evidence of malignancy, amputation of the breast performed.

Eccles obtains access to the cyst by splitting the nipple into halves.

Periductal fibromas also occupy the central area of the breast.

Simple Cysts.—*Serous cysts* occur at all ages, are rare, and consist of thin-walled cysts containing clear serous, mucoid, reddish or yellowish fluid. They vary in size from those containing a few drops to 500 c.c. of fluid, and on pressure do not empty through the nipple.

Treatment is excision.

Galactocele (*milk cysts, lacteal cysts*) are retention cysts containing milk or its derivatives. Usually single, unilocular, occasionally multilocular; they vary in size from that of a pea to a man's head, the contents being milk-like, buttery, or cheesy in character. They develop during or after pregnancy or lactation, and may persist, disappear after lactation, or evacuate through a duct. Rarely they develop in the axilla.

Treatment.—Excision, preferably by the Thomas-Warren incision, although recovery has followed evacuation through a small trocar. If the breast has been destroyed by pressure or atrophy, amputation may be desirable.

Involution Cysts: *Blue dome cysts, cysts from chronic interstitial mastitis, Schimmelbusch's disease, Reclus' disease, Brodie's disease, chronic cystic mastitis, cystadenoma* is a very common disease, which often greatly alarms the patient and has led to the unnecessary removal of many breasts. The cysts are multiple, scattered through the breast especially toward the periphery, forming tense rounded masses with thin walls, from the size of a pin-head to the size of a marble or an egg. These cysts develop between the ages of thirty and sixty years, during the involution of the breast or at the time of menopause. While *cystic mastitis* occurs at the age, and under conditions of involution that favor malignant change in the breast; there is no convincing evidence that the cystic degeneration is a precancerous lesion (Bloodgood). *Treatment:* Where the cysts are few in number, they may be treated by aspiration or excision. As the interstitial process continues other cysts will probably form, so that the patient often must be content to continue with the cystic disease, or else submit to amputation of breast. In case of doubt, or if there is induration or solid tumor formation, the breast should promptly be explored by the knife.

Parasitic cysts are rare. Small hydatid cysts of the breast may be excised *en masse*, larger ones should first be injected with tincture of iodin or 2 per cent. formalin, excised, or evacuated and packed, and permitted to close by granulation. If the breast has been largely destroyed, amputation without opening the cysts should be carried out.

Cysticercus disease is characterized by hard, movable, painless, fibrous nodules, situated at the periphery of the breast. The cysts may undergo suppuration, and the axillary gland may enlarge. *Treatment* is excision or, if suppuration has occurred, incision and application of tincture of iodin to the lining of the cysts, and packing.

Sparganum Mansoni.—The larvæ of tapeworms of undeterminate type have occasionally been found, usually in males, forming cystic masses the size of a

hen's egg in the pectoral muscle, with more or less pain and local tenderness. The worms may be found in the center of the cyst. Very rarely the Filaria medinensis or guinea-worm invades the breast, the characteristic embryos being found in the milky fluid that is discharged from the sore. *Treatment:* The very long, narrow worm may be extracted by cautious progressive winding upon a small stick.

Adenoma. 1. *Pure acinous adenoma* of the breast is rare, the section resembling that of the pancreas or parotid. Adenomas may become malignant, and should be excised.

2. *Fibro-adenoma, tubular adenoma*, the common type, consists of fibroconnective tissue with occasional long, narrow, tubular alveoli or canaliculi. The connective tissue: (a) May be homogeneous. (b) May show a special disposition around the canaliculi (pericanalicular fibro-adenoma). (c) May invade and distend the alveoli (intracanalicular fibro-adenoma).

3. *Intracanalicular fibro-adenoma (cystosarcoma phyllodes, cystosarcoma proliferum, myxoma intracanaliculare)* develops in women between the ages of twenty and thirty years of age, rarely after forty. The tumor is painless, well encapsulated, firm, rounded, movable, non-adherent, and without lymphadenopathy. It is a benign growth due to the ingrowth of fibrous tissue into the ducts and may reach the size of an orange or grape-fruit. Section shows grayish-white, smooth, homogeneous, lobulated tissue with polypoid excrescences resembling a cauliflower.

4. *Cystic adenoma (serocystic disease)* is a cystic variety of intracanalicular myxoma. The dilated cystic alveoli contain fibropapillomatous ingrowths. The intracanalicular growths occasionally become sarcomatous and break through the skin.

Etiology.—The growth is grayish white, encapsulated, non-adherent, round or oval, firm or elastic, depending on the amount of myxomatous change. The surface of section is convex, without juice; the lymph-nodes are not enlarged. Fibro-adenomata are often multiple or bilateral, develop in females between fifteen and thirty years of age, and may follow injury.

Symptoms.—Hard, rounded, freely movable lump in mammary substance; not causing traction or adhesion to skin, nipple, or underlying muscle. The growth is painless, or neuralgic pain may be present, increased at menstruation.

Treatment.—Fibro-adenomata should be enucleated, which, on account of the encapsulation of the tumor, is not difficult. Using the Thomas-Warren incision, the breast is turned upward, and the tumor removed from the under surface.

Fibromyoma occasionally occurs in the breast. Myxoma, angioma, chondroma, osteoma, and sebaceous cysts are rare; lipomas occasionally are found behind or at the side of the mammary gland, rarely in mammary tissue.

Sarcoma of the Breast.—Sarcomas constitute about 10 per cent. of the tumors of the mammary gland. About two-thirds are spindle-celled, about one-third round-celled, and one-twentieth giant-celled. Cystic degeneration is frequent. The soft and round-celled sarcomas are the more malignant.

Etiology.—Occur at any age without relation to lactation or pregnancy, and are much more common in the female breast.

Symptoms.—The tumor is round or oval, elastic or semifluctuating, usually

encapsulated, rapidly growing, and painless. The round-cell sarcoma is more rapidly growing and softer than the spindle-celled type. Sudden increases in size occur from hemorrhages due to the imperfectly walled blood-spaces in the tumor. Large vessels radiate in the overlying skin, which finally becomes reddened, ruptures, and a fungating necrotic and hemorrhagic mass protrudes. Secondary involvement of the lungs, liver, brain, or other internal organs is common, but adjacent lymphatic nodes are seldom affected.

Treatment.—The entire breast and overlying skin should be excised, and if there is any involvement of the axillary lymphatics or pectoral muscles these should be removed. Radiation is a useful palliative treatment for advanced, inoperable, and recurrent growths. Sarcomata show more rapid retrogression under radiation than do carcinomata; often rapidly subsiding, but later tending to recur and to progress to a fatal issue.

CARCINOMA OF THE BREAST

Carcinoma constitutes 80 per cent. of the true tumors of the mammary gland. In women carcinoma involves the breast more frequently than any other organ except the uterus.

Etiology.—(1) White race, rather than negro or aborigines, the poorer class more than the well-to-do. (2) Female sex, 100 to 1. (3) Age, usually between forty and sixty years, average fifty years; rare before puberty, unusual before thirty-five. (4) Pregnancy and lactation, less frequent in single sterile women. (5) Heredity, a family history of carcinoma is present in 15 per cent.

Fig. 693.—Section of normal mammary gland.

Not the carcinoma, but a predisposition or susceptibility is transmitted. (6) Traumatism is recalled by the patient in 20 per cent., but evidently is usually coincidental. More important than a single transient injury is repeated irritation, as from corset pressure, chronic mastitis, old scars, or occupation.

Usually the tumor is single and unilateral. It is bilateral in about 6 per cent. and about 60 per cent. involve the upper lateral quadrant of the breast.

Varieties.—(1) Spheroidal-celled carcinoma, the most common, growing from the acini of the gland. (2) Columnar-celled or duct carcinoma, from the ducts. (3) Squamous-celled epithelioma, from the nipple.

Clinically the tumor is (1): Hard or *scirrhous* from an excess of fibroconnective tissue, the most common form; or (2) soft, *medullary* or *encephaloid*, and rapidly growing; or (3) gelatinous or *colloid*, relatively rare.

Carcinoma Spreads: (1) By contiguity or direct invasion of adjacent structures; the skin, underlying muscles, chest wall, pleura being involved. (2) By permeation (Handley) of the lymph-spaces. Cancer-cells invading lymph-spaces excite a perilymphatic fibrosis, followed by contraction of the newly formed fibroconnective tissue, with obliteration of lymph-spaces and contained cells; permeation occurs in all directions with the main growth as the center, and precedes the obliterative fibrosis which, therefore, fails to check the spread of the disease.

Lymphatic Involvement.—*Primary:* Axillary, retropectoral, retrosternal, supraclavicular, paramammary nodes.

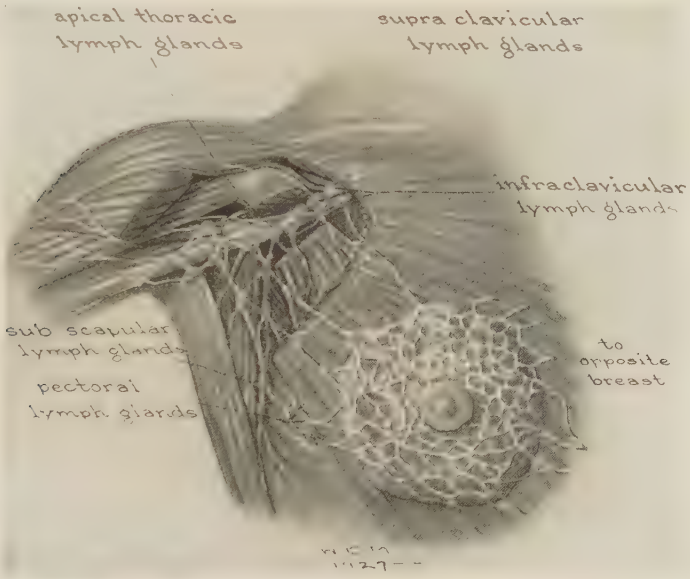


Fig. 694.—Carcinoma of the mammary gland. Lymph-nodes commonly involved in the early metastasis of the growth.

Secondary: Deep, cervical, diaphragmatic, hepatic, supraxiphoid, intercostal, and inguinal.

The lymph-nodes first involved are the axillary, including the pectoral, apical, and subscapular nodes. From the axillary glands, the secondary outlying nodes of the posterior triangle of the neck and in the mediastinum may be affected. The mediastinal lymph-nodes may also be invaded primarily by the lymph-vessels which accompany the perforating branches of the internal mammary artery. From the anterior mediastinum extension occurs to the liver and peritoneum.

Transcœlomic implantation depends upon the diffusion of cancer-cells through large serous sacs, as the pleura and peritoneum. Metastasis through the blood-vessels is less common and usually occurs later in the course of the disease.

Symptoms.—1. *First Stage:* Small, slowly or rapidly enlarging, irregular or craggy, hard nodule embedded in the mammary tissue, best felt between the flat hand and chest wall. The growth is not tender, although a slight stinging, sticking, or pricking sensation is often mentioned. There is a slight flattening of the overlying skin, especially when an attempt is made to lift the skin. The nipple or areola may show deviation toward the growth. The axillary glands are not enlarged, the general nutrition of the patient is not affected. This is the stage of successful operability, when 80 per cent. of the patients remain free from recurrence after a thorough operation.

Fig. 695.—Scirrhous carcinoma of the breast, showing flattening of the overlying skin and deviation of the nipple toward the growth.

The diagnosis should be confirmed by incision, and followed by immediate extirpation.

2. *Second Stage:* A hard craggy growth is felt by the flat hand embedded in the tissue of the mammary gland, the overlying skin is flattened or depressed and adherent. If the growth has invaded the pectoral muscle, the tumor moves transversely to but not in the direction of the muscular fibers. The nipple is higher on the affected side, inclined toward the growth, or flattened, depressed, or umbilicated. The areola is distorted and pulled in the direction of the growth. The lateral and apical axillary glands are enlarged, hard, and somewhat irregular and craggy. Intermittent lancinating or neuralgic pains radiate from the growth without local tenderness. In this stage, while radical operation gives freedom from recurrence in only 20 per cent., it is the best known treatment.

3. *Third Stage:* The growth is fixed to the skin, to the underlying pectoral muscles, and frequently also to the underlying chest wall, so that it cannot be moved in any direction.

The *skin* may show the following changes from malignant invasion: (a) Dusky red or purplish macules a few millimeters to several centimeters in diameter. These may be discrete or confluent, are without sharply defined borders, and may cover considerable areas of the skin. (b) Dusky reddish papules, the size of a pinhead or larger, which are firm and fixed in the skin. (c) Pig-skin (orange-skin, or orange-rind skin)—the skin is thickened, brawny, coarse, firm, with enlarged glandular openings, no longer pliable and frequently fixed to the chest wall. When the thick, inelastic, cancerous, infiltrated skin encases the chest like a plate of armor, the condition is termed "cancer en cuirasse." A serous and bloody discharge from the nipple is only occasionally observed. (d) Ulceration—the skin overlying the growth tends to ulcerate. The ulcer has a thick elevated irregular border, a granular irregular necrotic base, and a foul ichorous discharge.

The *lymph-vessels* are obstructed, the axillary lymph-nodes large and fixed to the skin, chest wall, or axillary vessels. The supraclavicular lymph-nodes are often also enlarged. From the lymphatic obstruction the arm becomes swollen, edematous, and brawny, beginning on the medial posterior surface; the skin of the fingers and hands finally becoming so swollen as to be of little use. There is a sense of weight and severe pain referred to the arm.

Metastasis to bone is common, especially at points where the lymph-vessels of the deep fascia are continuous with the periosteum, as at the upper end of

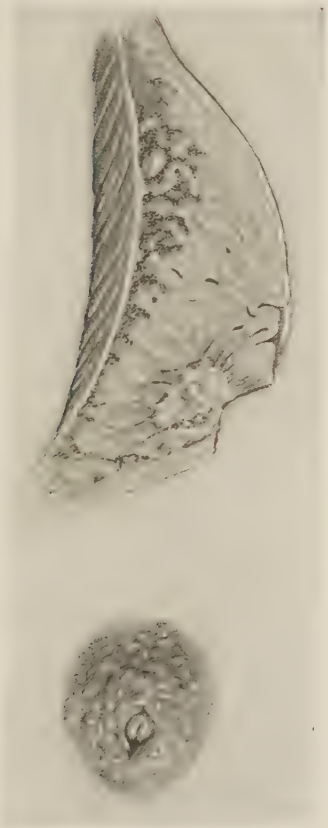


Fig. 696.—Scirrhous carcinoma of the breast: Later stage with ulceration and retraction of the nipple.

Fig. 697.—Advanced carcinoma of the breast with deep ulceration, and umbilication of the nipple.

the femur, the upper end of the tibia (insertion of patellar ligament), the upper end of the humerus (insertion of deltoid). The bodies of the vertebræ, the clavicle, the ribs, and the sternum are also frequently involved, with secondary pathologic fracture or pressure-symptoms. In the long bones a fracture may be overlooked, and the condition mistaken for a neuritis, sciatica, or lumbago. From the bodies of the vertebræ the growth may press upon the posterior rami, producing intense root-pains.

Fig. 698.—Cancerous erythema. Irregular violet-colored macules are present about the base of the neck due to malignant invasion of the lymphatics of the skin. There is a large primary carcinoma in the left breast which is elevated and the nipple retracted. An advanced and hopeless type of disease is indicated. (After Jacob.)

Fig. 699.—Nodular metastasis of the skin from carcinoma of the right mammary gland. (After Jacob.)

Metastasis to Internal Organs.—Secondary growths occur in the lung, pleura, mediastinal glands, liver, brain. In the lung, with hematothorax, cough, and dyspnea; in the peritoneum, with ascites; in the brain, with headache, monoplegia, or hemiplegia.

Special Varieties.—**Atrophic scirrhus** develops usually in thin women over sixty years of age. The growth is of very slow evolution and may last for from ten to twenty years with a marked development of the restraining fibroconnective-tissue stroma, a reduction in the size of the growth (*withering scirrhus*), and often, chronic ulceration. The ulcer is rather superficial and may give little trouble. The patient may die from intercurrent affections or secondary growths in other parts of the body.

Mastitis Carcinosa.—A rapidly growing carcinoma of the breast, suggesting acute mastitis, occurs especially in women under thirty-five and not infrequently

Fig. 700.—Recurrent carcinoma with large ulcer after amputation of the right breast. Carcinoma of the opposite breast is present with retraction of nipple, "pig-skin," and "cancer en cuirasse." (After Jacob.)

after pregnancy or during lactation. The gland rapidly enlarges, becomes firm, brawny, painful, the overlying skin dusky red and indurated. Often incisions are made with the diagnosis of abscess. Brawny thickening of the skin and breast tissue, fixation, marked irregular enlargement of the axillary lymphatics, the absence of fluctuation, the rapid growth of a mass in the breast, are suggestive of the true condition. The tumor is of the encephaloid type.

Encephaloid carcinoma (*medullary carcinoma*) is a rapidly growing soft carcinoma, characterized by many cancer-cells, large alveoli, and relatively little interstitial fibrous stroma.

Symptoms.—An oval or rounded mass, which rapidly enlarges and distorts the breast, the overlying skin becomes injected, the nipple is not retracted. The growth is soft and elastic and may feel hot from the vascularity. There is

early invasion and enlargement of the lymphatic glands of the axilla. Central necrosis followed by deep ulceration occurs early, with the formation of a foul fungating mass.

Colloid Carcinoma (*Gelatinoid Carcinoma*).—The alveoli contain translucent, yellowish, gelatinous fluid from colloid or mucoid degeneration of the cancer-cells. The growth is rather large, but the progress less rapid and the malignancy not as great as with the medullary carcinoma.

Cystic carcinoma usually occurs in association with a unilocular cyst of the breast; the cyst wall may undergo carcinomatous change, with local infiltration and extension.

Squamous-cell epithelioma of the nipple is more common in men than in women. A crusted papule appears upon the nipple, which slowly ulcerates; the ulcer being indurated, with the thickened elevated border and excavated irregular base characteristic of carcinoma. This growth is of rather slow evolution, and the malignancy is not intense.

Fig. 701.—Ulcerating epithelioma of the male nipple with secondary involvement of the pectoral lymph-nodes.

Diagnosis.—Every questionable lump in the breast should be considered as malignant until proved by operative exploration to be benign. Any recent growth which is firm or craggy, over which the skin is flattened or adherent, or toward which the nipple is depressed or deviated, is usually a carcinoma and requires immediate treatment. *Fibro-adenomata* are rounded or oval, not adherent, not craggy, and do not make traction on or distort the skin or nipple. *Cystic disease of the breast*, characterized by multiple rounded, tense growths that are not adherent or attached, is rarely associated with malignancy; but enlarging single cysts of the breast should be viewed with suspicion, and should be explored. Sarcoma of the breast may closely simulate encephaloid carcinoma, the lymphatic glands are not involved, the growth is encapsulated, the skin not infiltrated, and sudden increases in size occur from hemorrhages. Inflammatory symptoms and pain are minor.

Prognosis.—With a scirrhous carcinoma, operation in the first stage, before the axillary lymphatics have become enlarged, gives 80 per cent. chance of recovery, a 20 per cent. chance of recurrence. In the second stage, 20 per cent. chance of recovery and 80 per cent. chance of recurrence. In the third stage the treatment can only be palliative, radical extirpation of the growth is impossible. Recurrences in the supraclavicular glands occur as the first location in 15 per cent., the enlargement is, as a rule, followed by death within eighteen

months. Papillary, cystic, and intracystic carcinomas are the least malignant; next, intraductal carcinoma.

Preliminary excision is dangerous unless immediately followed by the radical removal of breast and lymphatics. If the patient is thin, and especially if above sixty years of age, the growth may undergo marked fibrosis and the patient live for years without treatment. Young patients, obese patients, and diabetics

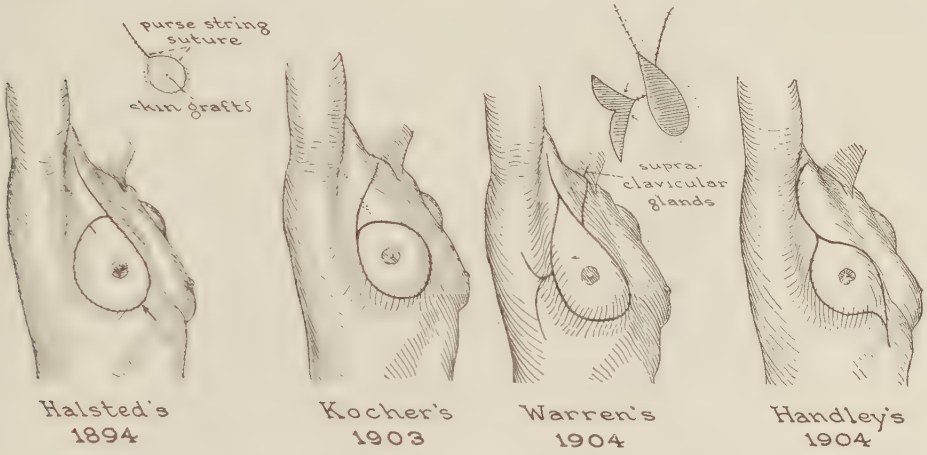


Fig. 702.—Skin incisions used for the radical amputation of the breast for carcinoma.

show less resistance to cancer, and are less amenable to operation, radium, or any form of treatment. Mastitis carcinosa indicates a very poor resistance, and usually is hopeless despite any form of treatment. Early recurrence usually follows extirpation of encephaloid growths.

The prognosis for epithelioma of the nipple is good provided metastasis has not occurred.

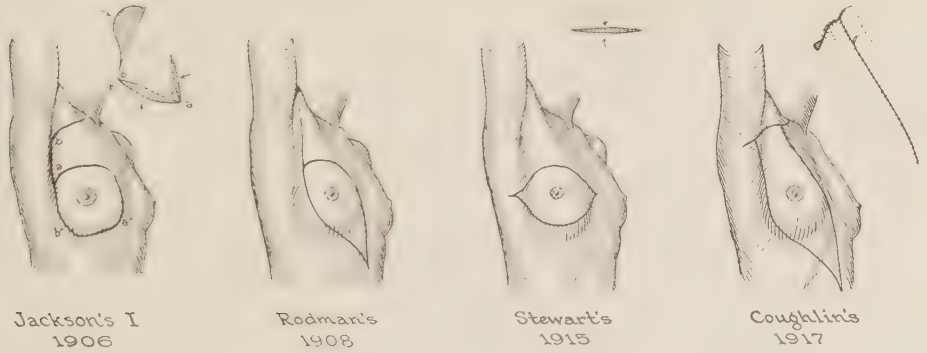


Fig. 703.—Skin incisions used for the radical amputation of the breast for carcinoma.

The average duration of life for untreated scirrhous carcinoma of the breast is three years; for medullary carcinoma, one year or less; for mastitis carcinosa, six months.

Treatment.—Radical operative extirpation is the preferred treatment for scirrhous carcinoma of the first or second stage; in the third stage of scirrhous

carcinoma, or for encephaloid carcinoma, mastitis carcinosa, and for long-standing, withering scirrhus of the breast, operation, as a rule, is not to be advised. For the aged woman who has had a withering scirrhus for eight to twelve years, no treatment is indicated, except local cleanliness and the application of non-irritating powders or ointments to the ulcerated surface. Radiation, the knife, or cautery may stimulate the growth. In encephaloid carcinoma the process may be arrested, the tumor reduced in size, and the mobility of the breast increased by careful *x*-ray or radium treatment, after which operative extirpation may be considered. Operation is sometimes desirable in advanced forms of carcinoma to free the patient of a foul or very painful ulcer; in these cases the operation cannot be a complete eradication, and it is possible that the

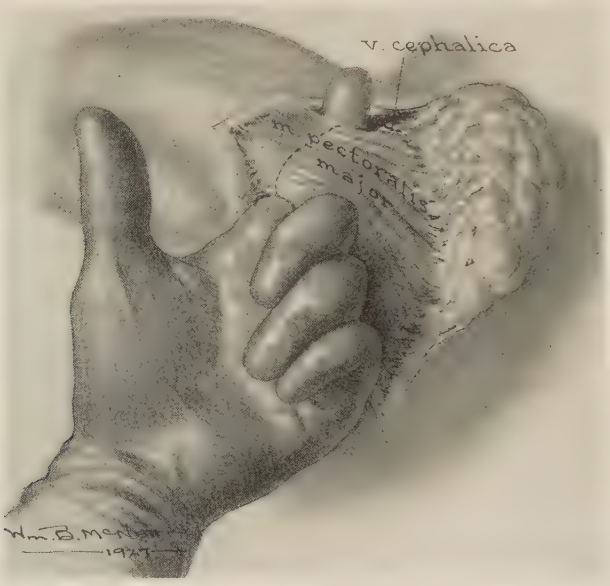


Fig. 704.—Radical amputation of the breast for carcinoma: Division of the pectoralis major muscle. The cephalic vein indicates the division between the pectoralis major and deltoid; the dotted line, the line for dividing the muscle.

operative traumatism may excite renewed growths or metastasis. As a rule, metastasis contraindicates operation.

Pre-operative radiation causes an inflammatory reaction favoring dissemination; postoperative radiation does not lengthen life or improve the final result from operation (Harrington, Mayo Clinic, 1928).

Operation.—Radical operation for carcinoma of the breast includes: (1) The removal of the entire mammary gland and adjacent tissue *en masse*. (2) Removal of the skin and fat overlying the tumor with a 6- to 8-cm. margin. (3) Removal of both pectoral muscles. (4) Removal of the fatty areolar tissue and of all axillary glands, including the lateral, the anterior or pectoral, the posterior or subscapular, the central or apical glands, and the medial or subclavicular glands. The deltoideopectoral glands may also be excised, and rarely the supraclavicular.

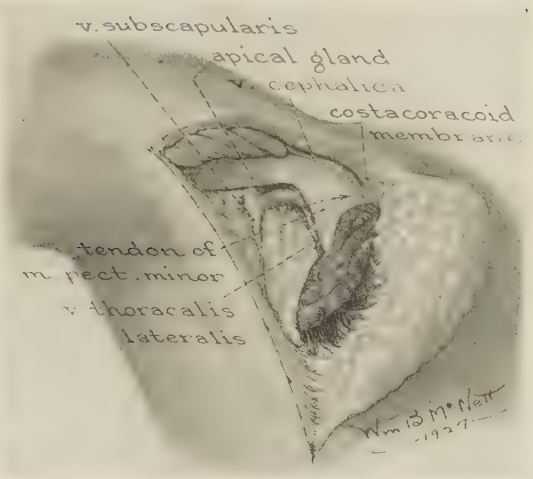


Fig. 705.—Radical amputation of the breast for carcinoma: The pectoralis major muscle has been divided, partially exposing the axillary contents; the tendon of the pectoralis minor is to be divided close to the coracoid as indicated.

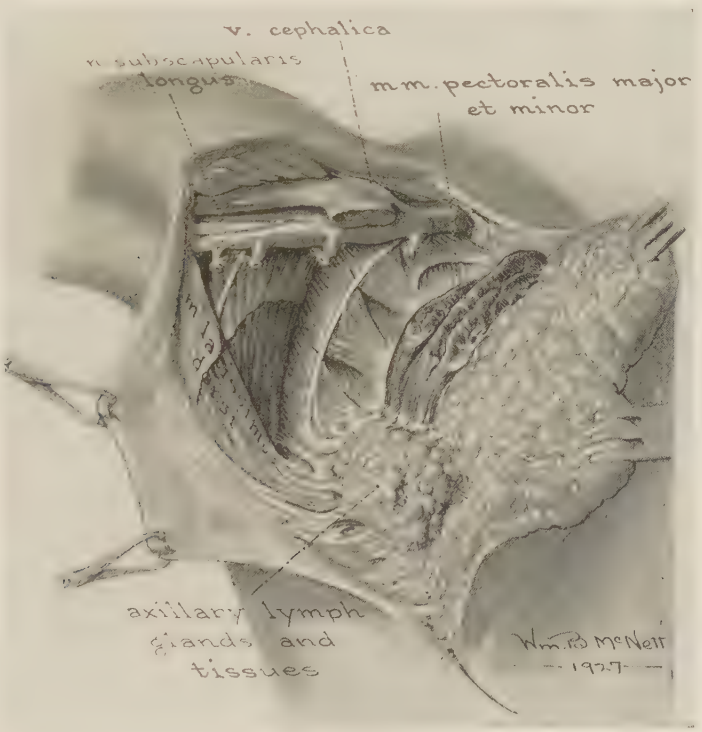


Fig. 706.—Radical amputation of the breast for carcinoma: The pectoralis major and minor have been divided, the axilla cleared of fat and lymphatics, the long subscapular and long thoracic nerves are preserved if possible. The axillary contents, muscles, mammary gland, and overlying skin are removed in one piece.

Plan of Operation.—*Anesthesia:* Ethylene-oxygen and nitrous oxid-oxygen are the preferred anesthetics, although ether may be used. Local anesthesia for radical amputation of the breast is a rather complicated and difficult procedure, although in elderly patients a limited field block associated with narcotism is often very satisfactory.

The *skin incision* should be so planned as to remove a large ellipse of skin overlying the tumor. If possible, it should be so placed that the scar will not fall in the axilla and thus limit the movements of the arm. The Coughlin or Jackson No. 2 incision, which are similar, is preferred. It is wise to first expose and clear the axilla, dividing the two pectoral muscles close to the humerus and coracoid, tying the branches of the axillary vein and artery close to the main trunks, and carefully clearing the vessels and nerves from all fatty and lymphatic tissue, removing the axillary contents, breast, tumor, and overlying skin and fat in one mass from the axilla outward. Unless there is adjacent infiltration the long thoracic nerve is spared, to supply the serratus anterior muscle. If the tumor has first been opened for exploration, the cavity should be packed with gauze wrung out of a saturated solution of chlorid of zinc, the overlying skin sutured; redisinfected,

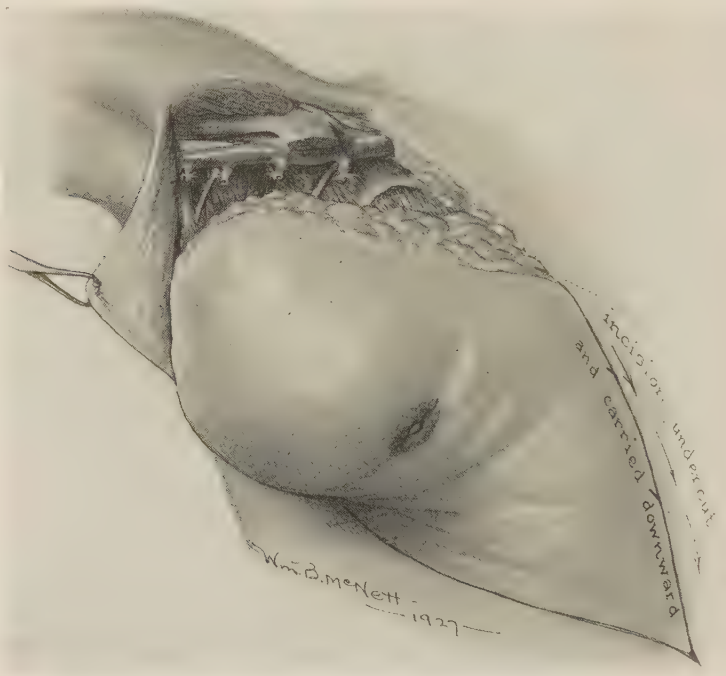


Fig. 707.—Completion of skin incision in the radical amputation of the breast for carcinoma.

sterile instruments, gloves, and wound draping used to replace those which may have been contaminated by contact with carcinomatous cells. By sufficiently undercutting and mobilizing the adjacent skin and opposite breast it is possible to close the large wound defect without resort to flap formation or skin-grafting. As drainage may carry infection into the wound it should be avoided, great care being taken to occlude every bleeding vessel. If a secondary serous or hemorrhagic effusion occurs in the wound, this may easily be evacuated by introducing a sterile grooved director between the stitches. The wound should be closed with the arm abducted, and abduction continued during the process of healing, to favor the early free use of the arm.

The patient usually is permitted out of bed on the third or fourth day, and allowed to leave the hospital on the seventh to the tenth day. A limited and usually superficial necrosis from wound tension is not infrequent when large areas of skin have been removed, but rarely does any harm except to prolong the time of wound healing. The mortality of the radical operation is 1 per cent.

Treatment of Inoperable Forms of Carcinoma of the Breast.—The Roentgen ray or radium may reduce the size of the growth, improve the local condition, and prolong life, but does not destroy the cancer-cells or prevent metastasis. To reduce the odor of ulcerated surfaces Condy's fluid or aluminum acetate may be used as a wash, followed by a dusting-powder of thymol iodid, bismuth subiodid, or fine powdered chloretone. Chloretone is antiseptic, anesthetic, and hypnotic, and if used too freely may cause stupor.

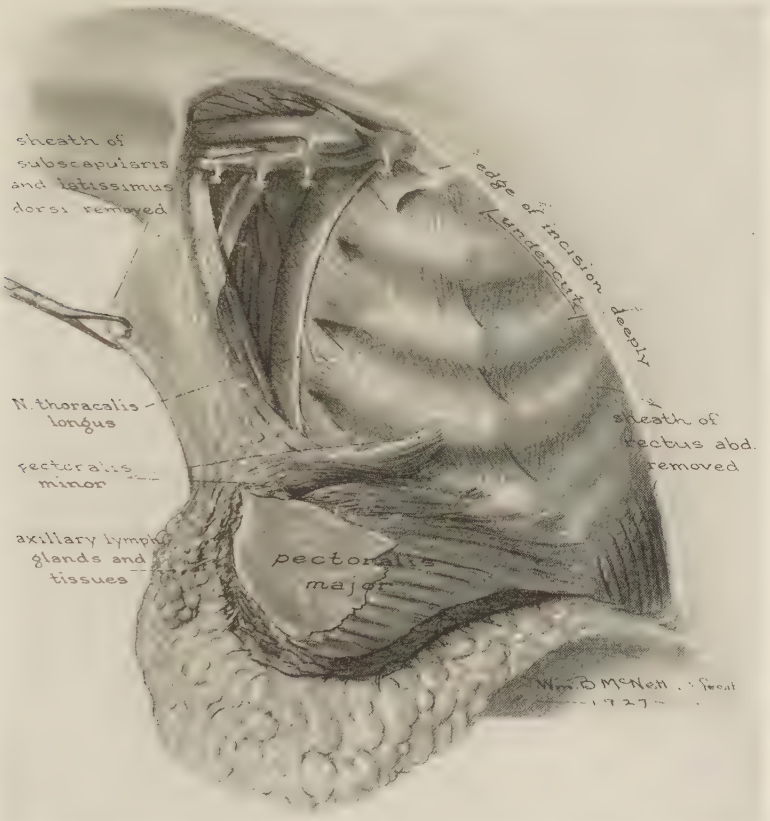

sheath of subscapularis and latissimus dorsi removed
edge of incision undercut deeply
N. thoracalis longus
pectoralis minor
sheath of rectus abd. removed
axillary lymph glands and tissues
pectoralis major
Wm. D. McNeil

Fig. 708.—Radical amputation of the breast for carcinoma: The skin incision has been completed, the ribs and intercostal spaces partially denuded, and the detachment of the pectoral muscles and other tissues to be removed is being completed. The skin margins are undercut to more completely remove the subcutaneous fat.

For a brawny arm strands of tubular silk (*Handley's lymphangioplasty*) may be introduced by long probes through multiple short incisions. The strands of silk buried in the subcutaneous tissue radiate from the thoracic wall and scapular region, down the arm and forearm to the wrist, and serve to reduce the lymphedema.

Pathologic fractures of the long bones should carefully be splinted to avoid the pain that comes from displacement of the fractured ends of the bone. The pain from a secondary carcinoma of the spine may be so great as to render

a spinal brace or support or the operation of chordotomy or root resection desirable.

For inoperable carcinoma before the menopause, oöphorectomy has been suggested (Beatson's operation) as well as many other methods, usually of little avail.

Plastic operations on the breast include: *Suspension*, *resection*, *contouring* by implantation of fat, *transplantation*, the one breast being transplanted to the opposite side. These operations have a limited value. After contouring the gland by the introduction of fat, the patient or medical attendant may mistake the denser transplant for a developing neoplasm.

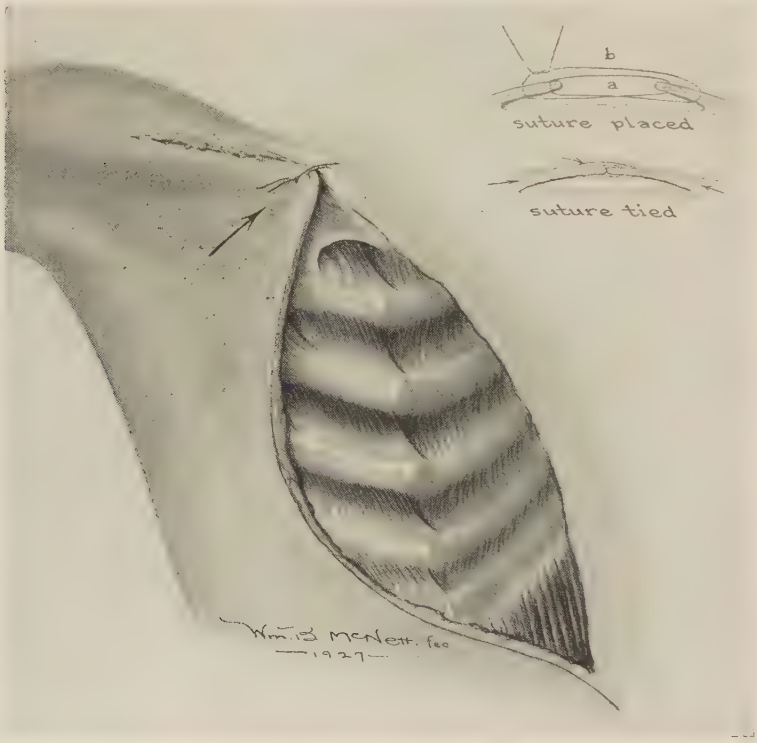


Fig. 709.—Amputation of the mammary gland for carcinoma: Method of wound closure showing useful type of combined relaxing and approximating suture.

Plastic Resection of the Breast (Dean Lewis).—Using an incision along the medial border of the areola, the nipple and areola are reflected, the gland excised, and the adjacent fat used to fill the cavity by a series of superimposed purse-string sutures of catgut. With the final accurate replacement of the areola by suture little deformity follows.

Hernia of the breast through the fascia around the areola is corrected in Harris' operation by three or four buried, concentric sutures of silk which encircle the areola and narrow the fascial opening. The sutures are introduced by a long needle through four equidistant incisions in the skin, about 1 cm. in length.

Fig. 710.—Amputation of the mammary gland for carcinoma: Double loop interrupted sutures are used to reduce the tension. By very wide undercutting and mobilization of the skin the large wound may be entirely closed. With careful hemostasis drainage is unnecessary, although an occasional serous effusion may require evacuation by a grooved director at the time of the first dressing, five to seven days after the operation. The scar is kept out of the axilla and the arm is dressed in abduction for early function.

CHAPTER XLIV

THE PLEURA

Pleural effusion may be: (1) serous (*hydrothorax*), (2) serofibrinous, (3) purulent (*pyothorax, empyema, purulent pleurisy*), (4) hemorrhagic (*hematothorax*), (5) chylous (*chylothorax*), or (6) gaseous (*pneumothorax*).

Hydrothorax (Serothorax, Pleuritis Exudativa Serosa).—The effusion of serous fluid into the pleural cavity occurs as an acute inflammatory process, preceding the formation of fibrin or pus. Chronic serous effusion in the pleural cavity usually indicates tuberculosis; occasionally it results from circulatory insufficiency, disease of the heart or lungs. In chronic polyserositis or rheumatism effusions occur within the chest.

Symptoms.—Pulmonary tuberculosis, if associated, usually is not advanced, and often is not suspected up to the time of the pleural effusion. The chest on the side of the effusion shows limitation of movement, flatness extending from the base upward, with diminished breath sounds and vocal and tactile fremitus. *Egophony* may be noted above the level of the fluid. The heart is displaced toward the opposite side, the liver and diaphragm downward. Slight evening fever is not uncommon. The patient may complain of sharp pain in the corresponding upper quadrant of the abdomen from irritation of the intercostal nerves. Tubercle bacilli may be found by animal inoculation or, rarely, in the sediment from the fluid under the microscope.

Prognosis.—Effusions reaching above the fourth rib are absorbed very slowly. Absorption may be stimulated by partial aspiration. Persistent unchanging effusions are common in tuberculosis.

Treatment is that of the underlying condition, as tuberculosis or heart disease. With improvement in the patient's general condition the fluid is often spontaneously absorbed. Evacuation of the fluid is indicated if it reaches a level above the middle of the scapula or fourth rib, when it produces pressure-symptoms, as dyspnea, pleural or intercostal irritation; and when there is no evidence of absorption after persistent treatment, including heliotherapy.

In the decompensation of heart disease repeated withdrawals of large quantities of serum from the chest emaciate and weaken the patient. To avoid this, the withdrawn fluid may immediately be reintroduced into the veins of the patient by an appropriate funnel, tubing, and needle.

Open or continued drainage for hydrothorax should never be used, as it will be followed by pyogenic infection of the pleural lining and secondary empyema, which is difficult to control, and in a tuberculous patient may last the rest of the patient's life, or necessitate repeated and very serious operations on the chest wall.

Hematothorax.—Effusion of blood into the pleural cavity follows injury to the chest wall and the contained organs. Chronic effusion of bloody serum into the pleura is characteristic of malignant disease of the lungs or pleura, and occurs in purpura and other serious blood dyscrasias.

Symptoms are those of free fluid in the pleural cavity, associated with evidences of hemorrhage, as pallor, increasing pulse-rate, fall in blood-pressure, and leukocytosis.

Treatment.—For acute traumatic hemorrhage, an ice-cap may be placed over the chest, and the patient kept in a sitting or semireclining position. One milligram of atropin given by hypodermic injection, 5 or 10 c.c. of alien serum given subcutaneously, and a small blood-transfusion are all useful. Morphin is helpful to control cough or restlessness. If the bleeding comes from the lung, the collapse of the lung by the injection of air or nitrogen into the pleural cavity may be of value. If the bleeding is severe from injury of the lung a pleurotomy should be done, and the bleeding point controlled by ligature or suture. In purpura, repeated small transfusions of blood are valuable, and in any case 5 to 10 c.c. of a 10 per cent. solution of calcium chlorid may be given intravenously to decrease the clotting time.

Pneumothorax is usually due to an opening from the lung into the pleural cavity, from traumatism or disease. Occasionally, with a valve-like penetrating wound of the chest wall, air is aspirated into the pleura from the outside, the valve action preventing the escape of the air. In such cases the lung may entirely collapse, and the pleural cavity become overdistended. In pulmonary tuberculosis, pyopneumothorax follows perforation of the lung, with the escape of air and infectious material into the pleura. Gas-forming bacteria, as the colon bacillus, in the pleural cavity also cause pyopneumothorax.

Air entering the pleural cavity without infection is usually rapidly absorbed, 100 c.c. of air being removed in a week or ten days.

Symptoms are hyperresonance, with perhaps metallic tinkling, and distant or absent breath sounds.

Treatment.—If the air is not causing symptoms, it should not be disturbed. The patient should be put in bed in a semisitting position, and the thorax partially immobilized by a bandage or strapping. Sucking wounds of the chest walls should be occluded or sutured after asepticization. If the air is producing undesirable pressure-symptoms, it should be aspirated through a small needle. In some cases repeated aspiration is required. Unless infection has occurred in the pleural cavity thoracostomy should be avoided, for it will lead to infection and a secondary empyema.

Pyopneumothorax should be treated like empyema, liquid injections or irrigations being avoided.

Chylothorax results from injury or occlusion of the thoracic duct within the chest, and is a rare condition that in about one-third of the cases has been associated with fracture of the spine. The other cases have been due, chiefly, to intrathoracic carcinoma that has involved the duct, or to filaria.

Symptoms are those of free fluid in the pleural cavity. The aspirating needle shows a creamy or milky fluid containing fat-droplets, lymphocytes, and sugar. The fluid is more creamy and contains more sugar than the fluid from the liquefaction necrosis in tuberculosis or carcinoma.

Pseudochylous fluid, an opalescent exudate, occurring most frequently in parenchymatous nephritis, rarely with neoplasms or after repeated aspiration, contains a lipoid soluble in alcohol but not in ether.

Prognosis.—Of itself chylothorax is not dangerous, the opening in the duct tending to close spontaneously, and the fluid to be absorbed. Chylothorax, however, is usually associated with severe fractures of the spine or malignant disease, which give a bad outlook.

Purulent pleurisy (**pyothorax, empyema**) is the accumulation of pus within the pleural cavity.

Etiology.—1. *Pneumonia:* Purulent pleurisy is the most common serious complication following lobar pneumonia. The pus is thick, yellowish or greenish-yellow, and frequently contains large masses of coagulated lymph, or *pus-clot.* In children, there is a greater tendency for pleural effusions to become purulent than in adults. Therefore, post- or meta-pneumonic empyema is most common in the first decade; after this, most common in the second and third decades of life.

2. *Influenza:* In severe epidemics of influenza, a polyserositis occurs with a tendency to large effusions, especially in the pleural cavity. A hemolytic streptococcus is found in the effused fluid and in the blood-stream. This was characteristic of the epidemic during the Great War. In the *ultra-acute type*, one or both pleural cavities fill with serum, and the patient usually dies from an overwhelming toxemia within twenty-four or forty-eight hours of the first symptom. In the milder forms or in patients with greater resistance, the early serous exudate becomes turbid and, by the end of one or two weeks, purulent.

Empyema also occurs as a complication of the exanthematous fevers, typhoid, typhus, and pyemia. It may follow contiguous infection, as tuberculosis, gangrene, or abscess of the lung, purulent osteitis of the ribs, suppuration of the mediastinal lymph-nodes, perforation of the esophagus, subdiaphragmatic infections, including abscess of the liver, subphrenic abscess, perinephritic abscess; suppuration of a hydatid cyst of the chest, wounds, or foreign bodies that enter the thorax.

Bacteriology.—1. *Pneumococcus* is the most frequent organism and gives a fair prognosis.

2. *Streptococcus*, especially the hemolytic form, varies greatly in virulence, is found in the fulminant form, and also in the subacute and chronic types.

3. *Staphylococcus* is rare, except as a contamination, as are also the Bacillus influenzæ, the B. typhosis, the gonococcus, the colon bacillus, the pneumobacillus of Friedländer, and the B. pyocyaneus. With all these organisms the predominant cell in the pus is the polymorphonuclear neutrophil.

4. *Bacillus tuberculosis* is usually difficult to demonstrate, except by animal inoculation. The small lymphocytes predominate in the pus.

The pus is very fetid when communicating with a bronchus, as in gangrene of the lung and in bronchiectasis.

Clinical Varieties.—(1) *Bilateral empyema* is rather rare. (2) *Loculated empyema* (encapsulated empyema)—the pus is enclosed by adhesions, between the lobes or on the surface of the diaphragm, often with indefinite physical signs. (3) *Total empyema*—the pus fills the entire pleural cavity. (4) *Pulsating empyema* is rare. The effusion is large, on the left side, often pointing, and the pulsation is transmitted from the heart, probably through pericardial adhesions.

Symptoms are those of a pleural effusion, plus evidence of a pyogenic infection. The intercostal spaces may be prominent and edematous.

Signs.—1. *Inspection:* Immobility of the affected side, displacement of the apex-beat, fulness of intercostal spaces, absence of Litten's diaphragm phenomena (in thin, healthy persons the shadow of the diaphragm is seen moving with respirations by oblique light on the axilla; movement is absent in pleural effusion and often in pneumonia, while in subphrenic abscess it may be abnormally high).

2. *Palpation:* Increased resistance, edema of the intercostal spaces in old cases, tactile and vocal fremitus reduced or absent, depression of the diaphragm, liver, and spleen.

3. *Percussion:* Flatness from fluid and compressed lung, beginning at the base posteriorly; may extend to the clavicle and to or beyond the midline, merging on the right side with the liver dulness, and on the left side with Traube's semilunar area, which is only obliterated by large effusions. Movable dulness is rather rare, and suggests pneumothorax.

Ellis' S-shaped Line: In moderate effusions with the patient sitting erect, the upper limit of dulness rises from the spine to the axilla and then falls to the sternum. When reclining the line slopes continuously from the spine downward, and is due to the position of the root of the lung.

Grocco's Paravertebral Triangle of Dulness: A triangle of relative dulness with the apex upward along the spine on the side opposite the effusion, the space being 2 to 8 cm. in width. It is attributed to bulging of the mediastinum or collapse of the lung, and is absent in pneumonia.

Skodaic resonance is a tympanitic area often present above the level of dulness.

4. *Auscultation:* Distant or absent breath sounds and absence of whispered pectoriloquy are noted over serous effusions.

Egophony: A nasal twang is often heard along the upper border of dulness, especially at the angle of the scapula.

Diagnosis is to be made from: (1) *Pneumonia.* Empyema is frequently mistaken for an unresolved pneumonia. In empyema the percussion note is flat and tactile fremitus is absent. It is a good rule to consider every supposed case of unresolved pneumonia to be an empyema until the presence of pus is absolutely disproved. (2) *Subphrenic abscess* and pericardial effusion are characterized by the peculiar area of dulness. (3) *Neoplasms* of the lungs. (4) *Great thickening of the pleura.*

A negative aspiration does not negative the presence of pus. Repeated aspirations may be required at different points. A Roentgen-ray examination is of value, but frequently is misinterpreted.

Prognosis.—(1) *Absorption* is rare, but occasionally occurs in children. (2) *Inspissation* of pus and chronic abscess is unusual except from tuberculosis. (3) *Empyema necessitatis:* The pus spontaneously ruptures through the chest wall, usually the sixth interspace, anteriorly. (4) *Perforation* into the adjacent organs or cavities, especially the lung, may occur with at times fatal asphyxia. Rarely the pericardium, stomach, esophagus, peritoneum, or the iliopsoas sheath (*psoas abscess*) is invaded.

Treatment.—*General Considerations:* The very toxic patient with acute

empyema should be treated by thoracentesis to relieve pressure and permit expansion of the lung. During a severe pneumonia or influenza, the moving of the patient into an adjacent operating room may be hazardous, and the aspiration should be performed in the patient's bed with as little disturbance as possible. Occasionally in children, seldom in adults, the pus does not re-form after aspiration. As soon as the toxemia from the primary pneumonia or influenza has been succeeded by the toxemia and pressure from the pyothorax, evacuation and continued drainage should be instituted. If the pus is serous, seropurulent, but not frankly purulent, or if it is of tuberculous origin, thoracostomy should be avoided and repeated aspiration used. The simple introduction of one or two tubes through a dependent intercostal space is the simplest form of thoracostomy, and should always first be tried for the very ill patient. If the tubes be-

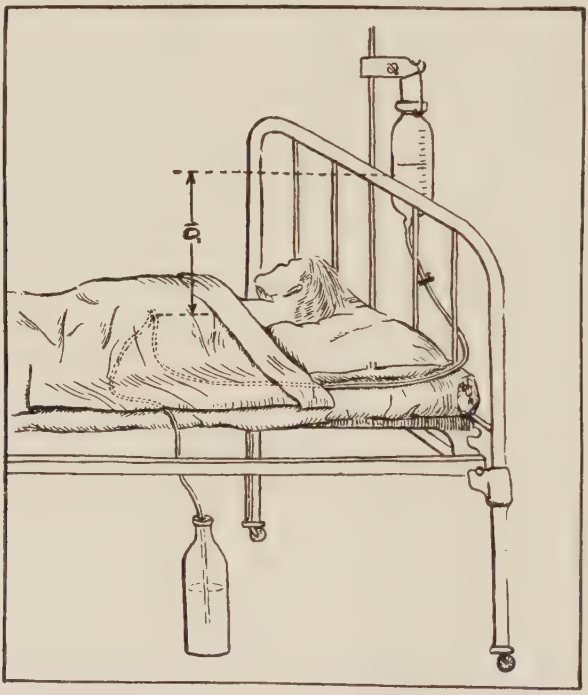


Fig. 711.—Arrangement for intermittent irrigation of the pleural cavity in empyema.

come occluded by pus-clots or solid exudate, these may be dissolved by the cautious instillation of Dakin's solution. If, from the tube-drainage, the patient develops shock, cough, or evidence of mediastinal flutter, the tubes should be closed temporarily. If the intercostal drainage proves to be insufficient, as it frequently will in adults, 5 cm. should be resected from one, two, or three adjacent ribs. In chronic empyema the lung may be so compressed, adherent, and obliterated along the vertebral groove that it cannot be felt by the hand introduced into the chest. For the residual chronic cavity, thoracoplasty or pulmonary decortication may be required. Irrigation of the cavity with Dakin's solution will overcome odor, dissolve and remove pus, transforming the secretion into a glairy, mucoid material. Introduced very freely so as to bathe every

portion of the cavity, at intervals not longer than every two hours, it will produce a surface disinfection but not kill bacteria under the surface. Therefore, if the pleural cavity persists and the external drainage opening is permitted to close after apparent disinfection with Dakin's solution or other surface disinfectant the empyema will, in most cases, recur some weeks or months later.

Obliteration of the cavity is essential for the cure of empyema by any form of treatment, and Dakin's solution has no special value in obliterating the cavity. Dakin's solution should not be used if there is a pulmonary fistula, for the entrance of the solution into the lung may be followed by serious or fatal asphyxia. While occasionally, especially in the early seropurulent stage of empyema, aspiration or the injection of antiseptics (including formalin, Dakin's solution, and the like) has been followed by recovery, drainage until the cavity has been obliterated remains the one dependable form of treatment in cases with a well developed purulent secretion.

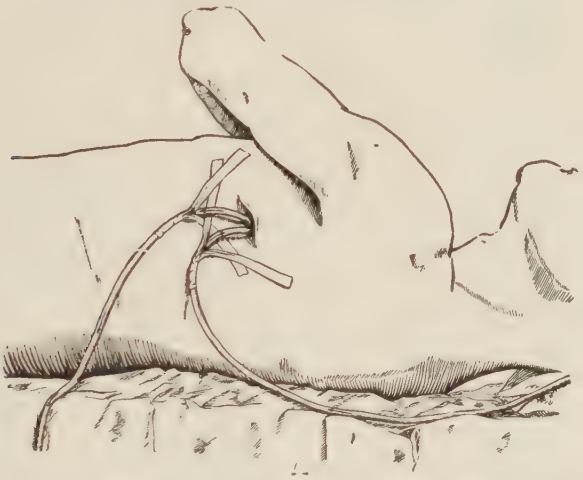


Fig. 712.—Thoracostomy, showing arrangement of the tubes for irrigation of the pleural cavity.

In acute empyema the use of poisonous antiseptics, including the free use of iodoform gauze or iodoform powder, or the injection of bismuth paste, should be avoided.

In a series of patients treated by the injection of bismuth paste through the thoracotomy opening, the symptoms ranged from a simple blue line on the gums to gingivitis and severe ulceration of the mouth.

Foreign bodies frequently slip into the pleural cavity and are overlooked in the treatment of empyema. In about 800 cases of empyema, treated by various surgeons, drainage-tubing, bits of gauze, or portions of rubber from the cigarette or other drain were found in 20. Great care should be taken to anchor all drainage appliances used in the chest. It should be remembered that a persistent sinus or empyema may be due to a foreign body.

Tumors of the Pleura.—These are usually secondary malignant growths, due to extension from the lungs, chest wall, or mediastinum; rarely endothelioma and sarcoma of the pleura occur as primary growths.

Endothelioma causes diffuse thickening or multiple nodules on the pleura, with or without blood-stained pleural exudate, friction sounds, dulness, pain on respiration. Occasionally, irregular temperature and marked leukocytosis are present. Both endothelioma and sarcoma occur more frequently upon the left side.

Diagnosis is made by the roentgenogram, the exploring needle or punch, or an exploratory thoracotomy.

Prognosis is unfavorable and the *treatment* palliative.

Sarcoma of the pleura occurs as a single massive growth or as multiple nodules. It usually develops rapidly, with effusion of bloody serum and compression of the lung.

Secondary carcinoma or sarcoma of the pleura is common, and is characterized by the progressive effusion of bloody serum into the pleural cavity.

Diagnosis is made by the history, the study of withdrawn fluid, the evidence of associated or distant malignant disease, and the Roentgen study.

Treatment is *palliative*. Repeated aspirations often give too little relief to be worthy of consideration.

THORACIC OPERATIONS

Thoracentesis (Paracentesis Thoracis, Aspiration of the Thorax). The patient should be in a sitting or semisitting position. The points of election are in the seventh or eighth intercostal space near the angle of the scapula, or the sixth interspace in the midaxillary line. In any case the needle should be introduced well within the area of dulness, should hug the upper border of the rib to avoid the intercostal vessels and nerves, and should be large enough to permit the escape of thick pus. The introduction of the needle below the eighth interspace is dangerous, as the needle may traverse the pleural cavity and perforate the diaphragm. With a trocar or large needle it is desirable to first nick the skin to facilitate the entrance of the needle and reduce the chance of infection. If, after introduction, the needle oscillates with respiration, it is probable that it is in the lung or diaphragm. As soon as the needle has entered the pleural cavity, it is connected with a Potain aspirator. If the fluid becomes bloody it indicates that the point of the needle is injuring the lung or other tissue, and it should be moved or withdrawn.

Recurrence.—The fluid may reaccumulate, rendering it necessary to repeat the paracentesis. Repeated recurrences may be treated by injecting 5 to 10 c.c. of the fluid subcutaneously as an autogenous vaccine; by injecting (after careful consideration) 1 c.c. of tincture of iodin, or 0.1 mg. of tuberculin dissolved in 10 c.c. of water, into the pleural cavity.

Pleurisy en Blocquées (*Blocked Pleurisy*).—In old pleuritic effusions with rigid containing walls, or with tension of the fluid less than that of the atmosphere, no fluid may escape from the needle until air or liquid is introduced into the cavity as by a second needle or incision.

Indications.—Thoracentesis is used for diagnosis, to relieve pressure-symptoms from fluid accumulation in hydrothorax, as a palliative measure in empyema, as a curative measure occasionally in children, or as a palliative treatment where the patient is not in condition to withstand a more serious operation. It is the preferred operation for tuberculous effusions into the pleura.

Dangers of Paracentesis.—(1) *Cough* from expansion of the lung—stop the aspiration. (2) *Faintness* from release of pressure and the shifting of the heart—discontinue aspiration, give aromatic spirit of ammonia or other diffusible stimulant. (3) *Acute edema of the lung*, and albuminous expectoration with death.

Avoid by slow, very gradual aspiration, stopping with the first unfavorable symptom. (4) *Sudden arrest of the heart*, from acute dilatation or from myocardial degeneration, is to be treated by intravenous and intracardiac injections of adrenalin, precardial percussion, or cardiac massage.

Thoracotomy is an incision through the chest wall.

Thoracostomy (*pleuracostomy*) is an operative opening, made through the chest wall, which is kept open for purposes of drainage.

1. **Trocar-tube Method.**—An incision, 2 or 3 cm. long, is made under local anesthesia over one of the lower intercostal spaces overlying the fluid, preferably at the posterior axillary line over the seventh or eighth intercostal space. Through this skin incision the largest trocar that will pass between the ribs is thrust into the cavity, and the stylet withdrawn. Through the cannula a graduated rubber tube is introduced into the pleural cavity, and the cannula is now withdrawn, leaving the rubber tube in place.

Fig. 713.—Babcock's trocar for the introduction of drainage-tubes into an empyema cavity.

For better drainage the trocar may be again introduced, and a second rubber tube inserted. The rubber tubes are now withdrawn until not over 3 cm. project within the pleura, and are anchored to the chest wall by silkworm-gut or silk sutures. A dressing is applied, and the patient is placed in bed in the Fowler position. The tubes run to receptacles on the floor, the open lower ends being kept submerged in antiseptic solution. This dependent, air-tight drainage-system produces a negative pressure within the pleura. The tubes should be carefully watched to prevent displacement

Fig. 714.—Exploratory thoracotomy. Free intercostal incision has been made and the ribs are being separated by the rib-spreader.

or obstruction. Obstructing pus-clot may be removed by injection or irrigation with warm Dakin's solution. The method is usually curative for the empyemas of children.

Pneumothorax occurs when air-tight drainage is not used. Subcutaneous emphysema and secondary abscess of the thoracic wall are usually due to insufficient incision of the skin, and should be treated by enlarging the external opening and providing for free drainage.

2. **Minor Intercostal Thoracotomy or Pleuracotomy.**—A transverse, oblique, or vertical incision is made over or adjacent to the selected intercostal space, the intercostal muscles and pleura exposed, divided, and one or more large drainage-tubes introduced.

3. **Major Intercostal Thoracotomy or Pleuracotomy.** –This is used for exploration of the chest, and for operations upon the lungs and other intrathoracic organs. The sixth intercostal space usually is selected, and an incision made from the angle of the adjacent ribs nearly to the costochondral junction. The intercostal muscles and pleura are divided for the length of the incision, bleeding arrested by ligature or suture, and a rib-spreader or powerful self-retaining retractor introduced (Friedrich, Sauerbruch, DeQuervain, or Lilienthal retractor, or Babcock rib-spreader). The ribs can be separated 7 cm., giving sufficient room for the introduction of a small hand into the pleural cavity. If more room is required, greater pressure with the fracture of one or both adjacent ribs may be used, or the sixth rib may be divided anteriorly, stripped from its pericostal investments back to the angle and temporarily hinged outward, to be replaced if the wound is later closed, or removed if drainage is instituted. In empyema, major thoracotomy is only used for mobilization of the lung, separation of adhesions, exploration and opening of cavities in very chronic conditions. If drainage is unnecessary, major thoracotomy is completed by passing one or several strong ligatures of No. 2 or 3 chromic catgut around the adjacent ribs, closing the opening by forcing the ribs together. The external divided muscles and skin are then sutured.

Fig. 715.—Babcock's costal periosteotome.

Fig. 716.—Costotome for dividing the ribs.

4. **Costectomy (Thoracotomy with Rib Resection).** –If the intercostal spaces are too narrow for effective drainage, the resection of one or more ribs, preferably in the mid or posterior axillary line, is necessary. The rib or ribs are exposed, the overlying periosteum incised, and with a costotome the periosteum and intercostal vessels stripped off. With a Gigli saw, a costotome, or Liston's bone-cutting forceps the rib is divided in two places, and the section removed. If, after removing portions of two or more ribs, there is insufficient room from displacing the intercostal vessels and nerves, the periosteum, vessels, and nerves should be divided or resected between ligatures introduced by a strong curved needle. After costectomy with retention of periosteum, the ribs re-form

Fig. 717.—Regeneration of a rib around a drainage-tube after costectomy for empyema.

and may produce a synostosis. A bony ring, forming about the drainage-tube, may contract the drainage opening and necessitate a second costectomy.

After thoracostomy, the expansion of the lung is favored by the regular use of "blow bottles" (*Wolff's bottles*) or other forced expiratory exercises, or by aspiration. Aspiration may be applied to the drainage-tube, or a Bier's cup placed over the opening in the chest. In chronic cases where the lung is collapsed, bound down by adhesions, and does not expand, a permanent pleural cavity remains, the walls of which secrete pus so that permanent drainage is required.

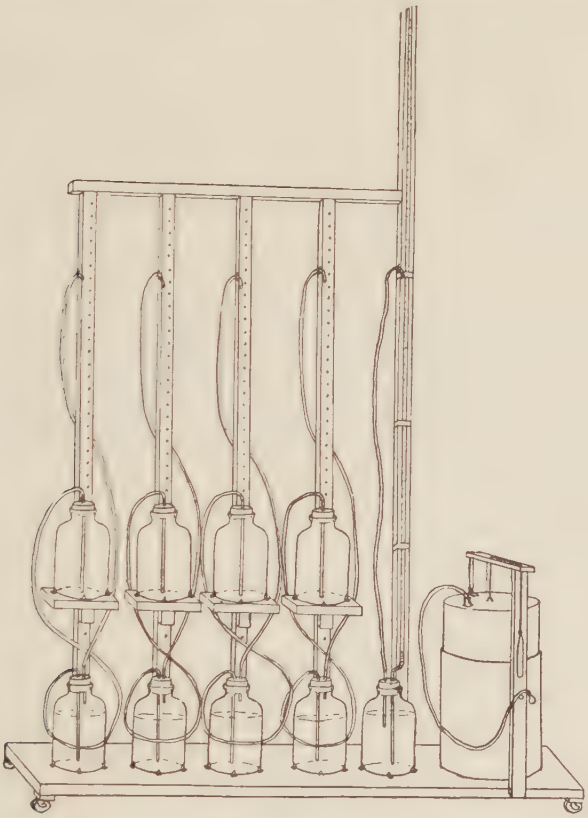


Fig. 718.—Spirometer and "blow bottles" for expanding the lungs after operations upon the pleura. Water is blown from the lower bottles to the upper, the degree of pressure being regulated by the height of the upper bottles.

To obviate this, the lung may be liberated so that it will expand and fill the thoracic cavity (*pneumolysis* or *pulmonary decortication*), or the thoracic wall may be mobilized (*thoracoplasty*) by the removal of sufficient a number of ribs, so that it collapses and comes in contact with the lung, obliterating the cavity.

Pulmonary Decortication.—Also called *Fowler's operation* (1901) or *Delorme's operation* (1894; published in 1902). By a major thoracotomy or rib resection, the adherent lung is exposed and liberated, and the thickened visceral, cortical, and diaphragmatic pleura sufficiently excised (*visceral pleurectomy*) to permit the lung to expand. If the patient cannot endure this serious operation, pleurotomy may be done by (1) the *liberation* of the edges of the bound down lung, or (2)

visceral pleurotomy by a long incision (Roux) or cross incisions (Ransohoff) through the sclerosed pleura. These operations often are ineffective. The visceral pleura usually is thin, tough, densely adherent, and its separation without the opening of air-cells and injury to the lungs is difficult. The parietal pleura, however, is often 1 or more centimeters in thickness, very rigid, and may be excised with portions of the overlying chest wall. Decortication is usually more difficult and dangerous than an operation for the collapse of the overlying chest wall.

Thoracoplasty is the mobilization of the chest wall by the resection of portions of three or more ribs.

Estlander's operation is a limited thoracoplasty, produced by the subperiosteal resection of three or more ribs without resection of the muscles or periosteum. Flap or multiple incisions are made through the skin as for a thoracotomy, as many ribs as can conveniently be reached being resected through each of the incisions. For extensive resections, a U-, T-, H-, or I-shaped incision may be used for better exposure. As a thick chest wall and thickened pleura may prevent sufficient collapse to obliterate the cavity, the more extensive operation of Schede may be desirable.

Schede's Operation.—The rigid chest wall overlying the cavity is excised, including the ribs, parietal pleura, intercostal muscles, and periosteum; hemorrhage is controlled, and the large flap of skin replaced. A huge U-shaped skin incision is made, beginning at the origin of the pectoralis major on a level with the axilla, curving downward along the lower border of the pleural cavity or the tenth rib at the posterior axillary line, to ascend between the scapula and spine to the level of the second rib. The large flap of skin, muscles, and other structures external to the rib is reflected upward, and all ribs, intercostal muscles, periosteum, and parietal pleura overlying the cavity are resected from the tubercles of the ribs to the costochondral junctions. In recent years the mortality of this operation has greatly been reduced by doing it in stages.

Plastic Operation.—For greater safety, instead of collapsing the chest, the pleural cavity may be lined by turning into it pedunculated flaps of skin or by using skin-grafts. The skin lining prevents the annoyance of the constant discharge, but it is obvious that a free permanent opening for aëration and cleansing of the skin-lined pocket is essential. Of somewhat limited value in obliterating the cavity is the carrying in of portions of muscle from the thoracic wall, particularly parts of the teres major and the latissimus dorsi.

CHAPTER XLV

THE LUNGS

Diagnostic Methods.—Tracheobronchoscopy is of great value in the location and removal of foreign bodies, and for the examination and treatment of bronchial conditions. The examination, to avoid dangerous reaction, should not be repeated oftener than once in seven or ten days.

Roentgenography.—Films are made before and after the introduction of substances opaque to the rays into the bronchial tree. The injection of lipiodol 40 per cent. of metallic iodin in poppy-seed oil [Sicard and Forestier, 1921] has not the danger of bronchial irritation of iodid solutions or the danger from absorption or cerebral complications following the injection of bismuth in oil.

Technic.—The injection may be *supraglottic*, *transglottic*, *subglottic*, or *bronchoscopic*. In the first, the base of the tongue and pharynx are anesthetized, the tongue pulled forward, and the oil dropped over the base of it as the patient inspires. In the transglottic method, after cocainization, the oil is injected through a curved cannula inserted between the vocal folds. In the subglottic method, a curved cannula is inserted through the cricothyroid membrane, and the oil injected directly into the trachea (Rosenthal). A 30 c.c. record syringe and a special curved needle are used. One hour before the injection, ½ to 1 grain of codein is given hypodermatically to control the cough reflex; three-quarters of an hour later the patient is directed to bend over and free himself of accumulated sputum. A wheal is raised in the midline just above the cricoid by injecting a 3 per cent. procain solution; the infiltration is carried to the level of the trachea, the trachea punctured, and 3 to 5 c.c. of a 3 per cent. solution of novocain injected. A minute incision is made, the trocar and cannula introduced, the trocar removed, and the injection made. With the patient upright, most of the oil will go into the right lower bronchus. For injection of the left side the patient should be inclined to the left, at an angle of about 30 degrees; for the right lower bronchus the inclination should be to the right side. Both lobes can be filled by injecting part of the oil while the patient is leaning to the right, the remainder while he is leaning to the left. For the middle lobe the injection is made with the patient recumbent on the affected side. The apex is difficult to inject; the patient may be held over the edge of the table in a lateral position, with the head lower than the hips. The amount used is 30 c.c. Roentgenograms are taken in both erect and recumbent positions, immediately after the injection. Lipiodol is coughed out of the bronchi in twenty-four hours, but may remain in the alveoli for a long time.

Bronchoscopic lung-mapping is carried out by the insufflation of carbonate of bismuth through the bronchoscope, using a powder blower and about 3 drams of the powder on one side at a time. It is used for the location of foreign bodies in relation to the bronchial tree, and to delineate the tracheobronchial tree.

Anomalies of the lung are rare, and include fusion of lobes, absence of a lobe, absence of an entire lung, bladder-like bronchial dilatations, and anomalies in the course of the bronchi. Valvular pneumothorax may occur as a result of a congenital pulmonary fistula.

The lungs have a glandular function, metabolizing fat. Roger has shown that the fat passing through the thoracic duct and subclavian vein largely disappear from the oxygenated blood leaving the lung.

Foreign bodies in bronchi, especially common in children under three years of age, include peanuts, artificial eyes from toys, safety-pins, beads, pills, peas, seeds, corn, and other substances. Usually the object passes through the right bronchus to the lower tube bronchus. The right bronchus is more directly in line with the trachea, and has a larger opening than the left.

Symptoms.—Paroxysmal convulsive cough, followed by cyanosis, dyspnea, wheezing, and secondary bronchitis and toxemia, after eating peanuts or after the inhalation of a foreign body. The signs vary, as the foreign body is occluding, non-occluding, fixed or moving, or producing a ball-valve action; and also with the degree of secondary local infection and irritation. Non-occluding bodies, such as safety-pins, often give little early disturbance. Occluding objects cause collapse, distention, or edema of the lung with retention of secretion. Pus may overflow into the opposite bronchus and lung, where it may be found and mislead the bronchoscopist. The lower right lobe is usually obstructed, with loss of breath-sounds, increased resistance on palpation, loss of vocal resonance, hyperresonance above the area of collapse, and increased temperature and pulse-rate.

Fig. 719.—Tack in the right primary bronchus, expelled spontaneously by coughing as the patient was about to enter the hospital. (Roentgenogram by Dr. G. C. Bird.)

Opaque bodies will show on the roentgenogram.

Sequences.—A purulent septic bronchitis, possible abscess of the lung, and even empyema as a rather late and rare complication. The bronchoscope shows infection of the larynx and trachea, with swollen granular mucosa, and with pus usually running from the lower right tube bronchus.

Symptoms may persist, after the removal of a foreign body, from a residual foreign body or a residual inflammation. A foreign body may shift, and be found on the opposite side from the pus and the physical signs.

Arachidic (vegetal or peanut) bronchitis is that due to the presence of vegetable bodies, which produce more irritation than metal or mineral substances. The obstruction may cause: (1) Emphysema from overdistention of the lung by air; (2) secretory emphysema from collection of secretions; or (3) atelectasis of one or more lobes of the lung. The foreign body may move up and down with respiration. The diaphragm on both sides is lower on expiration than on inspiration. If the foreign body is in the trachea, complete obstruction causes a rapidly fatal asphyxia.

Treatment.—Bronchoscopy and peroral extraction. Rarely pneumotomy.

Inhalation of Zinc Stearate and Other Powders.—*Etiology:* Infants playing

with zinc stearate or talcum cans may open them and inhale quantities of the powder. Talcum or soap-stone powder is removed by coughing, and seldom

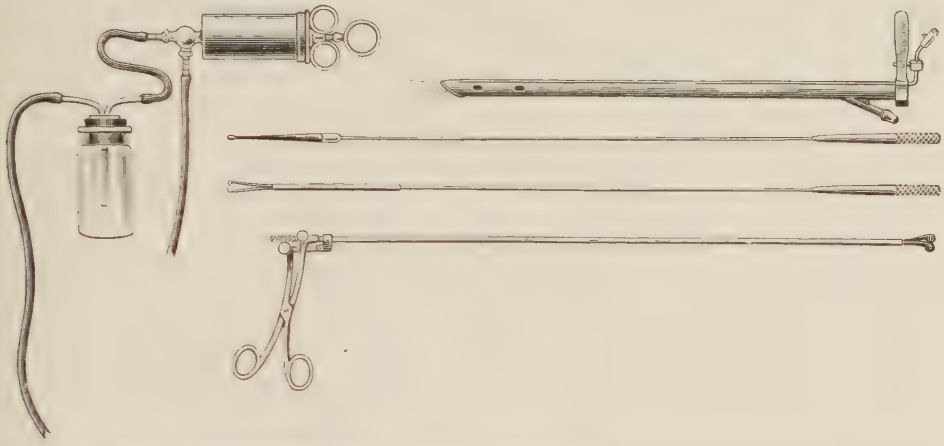


Fig. 720.—Jackson's bronchoscope, probe, bronchoscopic forceps, and aspirating bottle for secretions.

produces serious effects. Zinc stearate, however, adheres to the bronchial mucosa, is removed with difficulty, and has caused death.

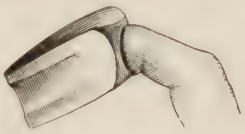


Fig. 721.—McKee-McCready bite-block used to hold the jaws apart in bronchoscopy.

Symptoms.—The child develops air-hunger and cyanosis, which pass on to coma, collapse, and death. There may be bronchial hemorrhage, hemorrhagic edema, or a traumatic bronchial pneumonia. There are three types, the *bronchitic,*

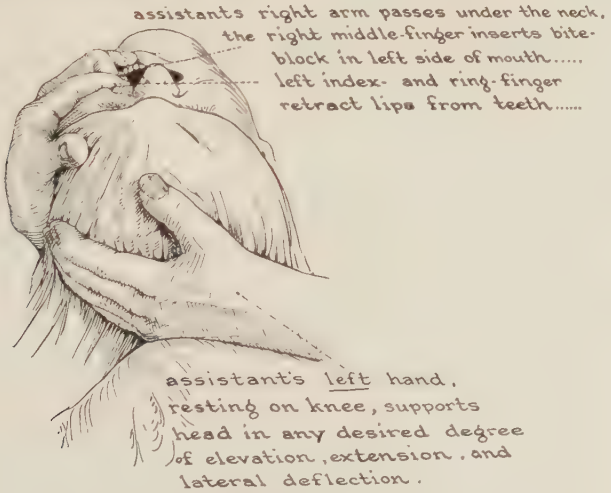

assistant's right arm passes under the neck, the right middle-finger inserts bite-block in left side of mouth..... left index- and ring-finger retract lips from teeth.....
assistant's left hand, resting on knee, supports head in any desired degree of elevation, extension, and lateral deflection.

Fig. 722.—Method of supporting the head in bronchoscopy.

the *emphysematous*, and the *cavernous*. The Roentgen ray shows the powder (1) chiefly at the hilum, with a radiating network over both lungs giving a marbled appearance; or as (2) nodular, sharp shadows with a jagged outline.

Treatment.—Syrup of ipecac and gastric lavage should be used to induce vomiting, gagging, or cough. Mucus should be removed by gentle swabbing of the mouth and pharynx, and a mustard bath given. Opiates and sedatives are to be avoided, and cough is to be encouraged.

Laryngeal dyspnea is dangerous and may require an immediate tracheotomy. It is recognized by the drawing in of the suprasternal notches at the medial ends of the clavicle and, often, of the intercostal spaces and epigastrium.

Wounds of the Lungs.—The lungs may be damaged with open or closed wounds of the chest. In closed injuries the lungs may be compressed, ruptured, or lacerated by a broken rib. From forced insufflation the pulmonary alveoli may

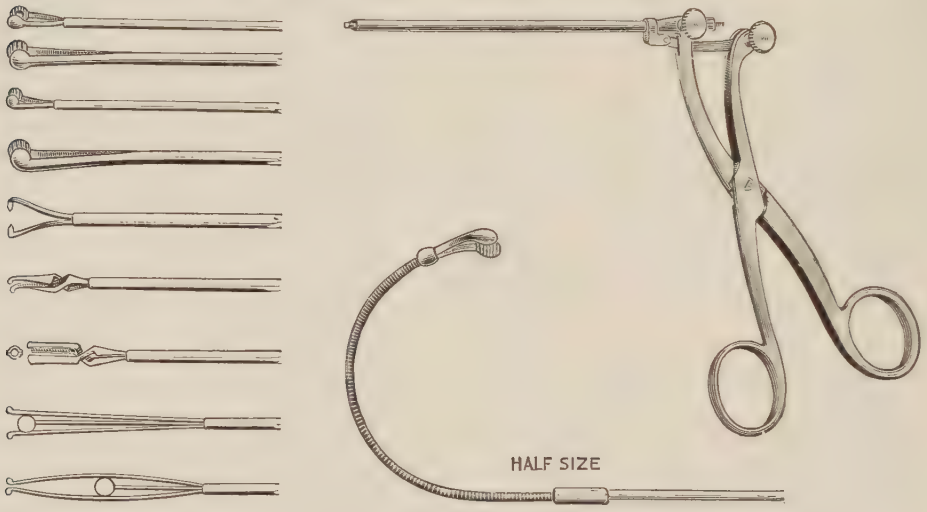


Fig. 723.—Jackson's forceps used for the removal of foreign bodies from the bronchi.

stretch or rupture. This has followed the use of the pulmotor in infants, the child dying two or three days after being resuscitated by the machine. Open wounds of the lung follow penetrating or perforating wounds of the chest wall, as has previously been described.

After injury, cough, hemoptysis, dyspnea, hemato- and pneumo-thorax, local or diffuse emphysema and collapse of the lung may occur. Perforating wounds of the lung, as by bullets of small caliber or by stabbing, are frequently followed by few symptoms and rapid recovery.

Secondary septic complications to be feared are: empyema, mediastinitis, emphysema, and, if the diaphragm has been perforated, peritonitis.

Treatment follows that outlined for injuries of the chest wall.

Operation for Injuries of the Lung.—Through a major thoracotomy incision, the lung may be inspected and palpated. Incisions and lacerations of the lung are sutured by fine round needles threaded with fine chromic catgut, hemorrhage being controlled by the suture or a ligature. The branches of the pulmonary artery may be tied. Foreign bodies entering from without, such as

bullets, shrapnel, shell fragments, are easily located by palpation through the soft lung-structure and removed by incision through the overlying lung; the lung sutured and, if there is no infection, the ribs approximated, and the wound closed without drainage. Foreign bodies entering the lungs through the air-passages, as a rule, are to be removed by bronchoscopy. In Villon's method, the instrument is introduced through an incision in the thoracic wall, and is guided to the foreign body by the fluoroscope.

Pulmonary hemorrhage occurs from: (1) *Bronchial vessels*, a part of the systemic circulation. (2) *Pulmonary vessels:* Pulmonary arteries have thin walls, with a blood-pressure one-sixth that of the general arterial circulation; the blood is dark, venous, and projected in feeble spurts, while from the bronchial arteries bright red blood comes in strong spurts. Hemorrhage from the pulmonary arteries and veins is usually controlled by collapsing the lung, or by the production of artificial pneumothorax. This may fail to control hemorrhage from the bronchial vessels. A portion of lung may occasionally be packed against the underlying diaphragm, but packing should never be used against the mediastinum. Atropin sulphate, 1/40 to 1/60 grain, may be given.

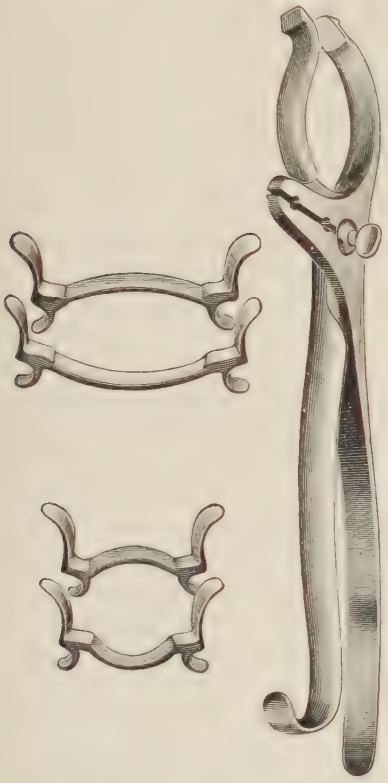


Fig. 724.—Babcock's rib-spreader and props for major thoracoplasty.

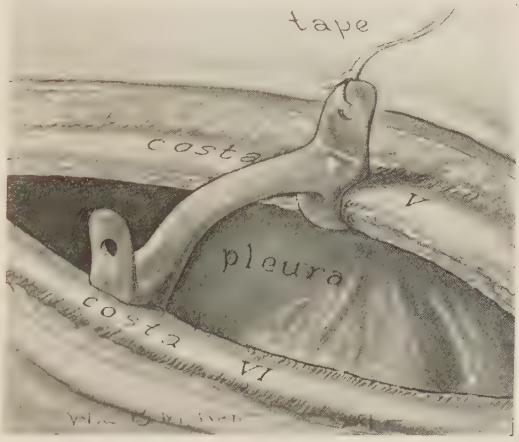


Fig. 725.—Exploratory thoracotomy: The separated ribs are held by a rib-prop, giving sufficient space for the introduction of the hand into the pleural cavity.

Pulmonary edema may rapidly disappear under: (1) *cording of the extremities* by rubber bands or tubing to prevent the return of venous blood to the body. This reduces the blood-pressure from 40 to 60 mm. of mercury in ten minutes and the preceding blood-pressure may not be regained until the cords have been removed for an hour (Lilienthal). The cords, which are placed close to the trunk, should not be left on for over twenty or thirty minutes. Cording is also used for hemoptysis. (2) *Osmotic methods*, such as intravenous injections of hypertonic salt solution, introduction of saline by mouth or rectum.

Massive Collapse of the Lung.—A condition in which one or more lobes of the lung lose their air, and collapse without separation from the chest wall, but with elevation of the diaphragm, depression of the chest wall, and movement of the heart and mediastinal structures toward the involved side.

Etiology.—Abdominal operations, especially appendectomy and herniotomy, rectal operations, fracture of the pelvis and femur, injury of the abdomen, chest, or buttocks; postdiphtheritic paralysis of the diaphragm, pneumonia, or poliomyelitis. The collapse is ascribed to a toxic effect upon the vagus, reflex collapse of the bronchioles, and secondary absorption of alveolar air. The type of anesthetic used is not a factor.

Symptoms.—The onset is usually sudden within twenty-four hours after injury or operation, with dyspnea, rapid pulse, cyanosis, irregular temperature to 102° F., scanty sputum becoming thick and mucopurulent but not bloody, and moderate leukocytosis (up to 20,000). Again, there may be little influence upon the pulse-rate, respiration, or temperature. The condition continues for from one to three weeks, and may be followed by rapid or slow reinflation of the lungs and re-establishment of respiratory function. Roentgenographic study shows dense lobar consolidation, or homogeneous or slight mottled consolidation of the entire lung, with displacement of the heart and trachea toward the involved side, narrowing of the affected side of the chest and of the interspaces, elevation and immobilization of the diaphragm. The increased density of the lung corresponds to that from pneumonia.

Diagnosis.—Characteristic signs of massive pulmonary collapse are: reduction of the width of the involved chest cavity, narrowing of intercostal spaces, elevated and immobilized diaphragm, retraction of heart and mediastinal structures, and change in the position of the apex-beat. If only the upper lobe is involved, a deviation of the trachea may be the chief symptom.

Prognosis.—Death rarely follows from the massive collapse alone.

Treatment is symptomatic. The use of circulatory stimulants and the inhalation of oxygen with or without the addition of carbon dioxid are suggested.

Abscess of the lung is much more common than was thought to be the case before the introduction of the bronchoscope.

Varieties are: *Acute*, *chronic*, *single*, *multiple*, *circumscribed*, *diffuse*, *endobronchial* (from aspiration), and *parenchymal* (from embolism and infarction).

Etiology.—(1) *Foreign bodies*, such as peanuts, grain, peas, buttons, artificial eyes from toys, are common causes in children. (2) *Tonsillectomy*, once in 3000 cases (W. F. Moore), from septic thrombi through jugular vein or by aspiration. (3) *Croupous pneumonia*, influenzal pneumonia. (4) *Septic emboli* from puerperal fever, pyemia, traumatism. (5) *Extension* from abscess of the pleura, liver, subphrenic abscess, suppurating bronchial glands, echinococcus cyst.

Symptoms are cough, expectoration of quantities of pus which may be creamy, odorless, or moldy, sour, sweetish, or fetid; or again, the sputum may be chocolate colored or like prune juice. There is fever, night-sweats, pain, and an area of pulmonary dulness. After tonsillectomy or in the embolic form, there is an incubation period of six days.

Diagnosis.—Abundant expectoration of creamy yellow pus containing elastic fibers and hematoidin crystals, with the physical signs of a cavity of the lung,

usually in the lower lobe, is suggestive of abscess. It may be difficult to differentiate from a bronchiectatic cavity. Roentgen and bronchoscopic studies show the localized area of pus or the presence of a foreign body.

The chronic cough, with expectoration (usually offensive) and an evening temperature of 99° to 100° F. continuing for weeks or months, is usually mistaken for tuberculosis. If the sputum is negative and the location of pulmonary signs is basal instead of apical, with tubular breathing, dulness, râles, crackling, and clubbing of the ends of the fingers, an abscess should be suspected.

Complications include pleurisy, empyema, gangrene of the lung, pericarditis, hemoptysis, abscess of the brain, and amyloid disease, and may be fatal.

Prognosis.—Mortality is 20 to 50 per cent.

Treatment.—1. *Prophylactic:* The third stage of general anesthesia in tonsillectomy or other operation on the throat should be avoided, as it favors the inspiration of septic substance from the throat into the bronchi. Operation also should be avoided during, or immediately after, acute infections of the respiratory tract. During operation, the mechanical aspiration of liquids from the pharynx and a low position of the head are desirable, and after operation cough should not be suppressed by sedatives and antibechics.

2. *Removal of foreign bodies.*

3. In abscess of the upper lobe, the *natural drainage* favors spontaneous cure. Central abscesses near the hilum may be treated by aspiration and injection (*Lukens-Yankauer return-flow tube*) through the bronchoscope every ten to fourteen days. One-half per cent. mercurochrome or 5 c.c. of 20 per cent. solution of gomenol in mineral oil may be instilled. The general condition of the patient should not be neglected, and sunlight, full diet, laxatives, and vaccines used.

4. *Postural Drainage:* The body of the patient is inverted over the side of the bed, the head being on the floor. The position is maintained from three to fifteen minutes, two or more times daily, for an abscess of the lower lobe.

5. *Artificial pneumothorax* may be tried for central but not for peripheral abscesses, for fear of empyema. If the sputum disappears after the pneumothorax, but later returns, a permanent collapse of the chest wall may be considered.

6. *Operative Drainage:* Pneumotomy is indicated when the abscess is peripheral, the pleura is involved, or in case other measures fail after six to eight weeks of trial. The operative mortality is about 35 per cent.

If the lung is not fixed to the chest wall, a two-stage operation protects the general pleural cavity. The first stage is a thoracotomy, with localization of the abscess. The overlying lung is stitched to the chest wall, and gauze introduced until adhesions have formed. The parietal pleura may be detached and sutured to the lung in the first operation. Several days later the gauze is withdrawn, and the lung penetrated into the abscess by cautery, knife, scissors, or forceps. A tube should be worn, and the wound kept open for six months or more.

Gangrene of the Lung.—A rather rare condition of putrefactive necrosis of the lung, due to anaërobic and other bacteria.

Etiology.—1. *Predisposing causes* include: Adult life, male sex, diabetes, alcoholism, and debility.

2. *Exciting Causes:* (a) A terminal condition in lobar pneumonia. (b) Secondary to the lodgment of foreign bodies in the bronchi or lungs. (c) Aspiration of septic material from paralysis of the muscles of deglutition, wounds of the pharynx, larynx, and trachea, rupture of a retropharyngeal abscess, from the eustachian tube in purulent otitis media (Volkmann), perforation of the esophagus into a bronchus from carcinoma or ulcer. (d) Rupture of an empyema, or subphrenic or hepatic abscess into the lung. (e) Metastatic, as from a septic pulmonary embolism following thrombosis of veins in the temporal bone in otitis media (Leyden). (f) Wounds of lung and fractured ribs, particularly gunshot wounds. (g) Complication of measles, smallpox, and typhoid.

Pathology.—(1) A *circumscribed* or infrequently (2) a *diffuse form* involving the entire lobe or lung occurs. Usually the mass is single, in the right lung, and near the base. The area varies in size from that of a pea to that of a fist. Section shows a dirty greenish-brown or black area, with a foul cavity lined by ragged masses of necrotic tissue, surrounded by a zone of marked congestion and edema, the pleural cavity usually being walled off by adhesions. Staphylococcus pyogenes albus and aureus are commonly present. The pleura is discolored, reddish-yellow, lusterless, and covered by fibrin.

Symptoms include: Extreme prostration and characteristic intense cadaveric fetor of the breath; with free expectoration of a foul greenish liquid, that settles into (1) an upper frothy mucopurulent layer, (2) a middle grayish-green layer, and (3) a dirty grayish-green lower layer, containing pus, fragments of lung, elastic tissue, and blood-clot.

Complications are: Purulent bronchitis, hemoptysis, pleurisy, pneumothorax, and occasionally abscess of the brain. If there is no opening into a bronchus, the odorous breath is absent.

Prognosis.—Recovery is rare without operation. If originating from perforation of the esophagus, if the gangrene is diffuse, has multiple foci or is bilateral, the prognosis is unfavorable. In the metapneumonic type the mortality of pneumotomy is 75 per cent.

Treatment.—Early pneumotomy and free drainage, with support and stimulation, are indicated when the patient's condition is not rendered hopeless by an associated meningitis, pyemia, carcinoma of the esophagus, or other incurable condition.

DISEASES OF THE LUNG

Hypertrophic emphysema is characterized by the dilatation of the pulmonary alveoli.

Symptoms are dyspnea, cyanosis increased by exertion, and usually a chronic bronchitis associated with a barrel-shaped thorax with increased anteroposterior diameter, wide intercostal spaces, increased sternal angle, and prominent cervical veins. There is hyperresonance on percussion, and on auscultation the expirations are prolonged, the inspirations short with râles and rhonchi.

Treatment.—Where there is fixation of the thorax, due to calcification of the costal cartilages or *Freund's disease*, Freund's operation may be tried. Freund's operation is intended to mobilize the rigid thoracic wall, and has been used for alveolar pulmonary emphysema and apical pulmonary tuberculosis.

Bronchiectasis.—Dilatations of the bronchi may be cylindric or saccular, the small and medium-sized bronchi being chiefly affected. A closed cavity may form or there may be multiple sac-like dilatations, with fibrosis and contraction of the intervening or surrounding lung tissue. Tuberculosis may be associated.

Pathology.—The lower lobe usually is involved, the walls of the saccules are smooth, lined with flattened epithelium, upon an atrophic muscular layer, the contents are fetid; the surrounding lung tissue is sclerotic; frequently there are associated pleuritic adhesions. A peribronchial or general fibrosis of the lung is usual.

Etiology.—The *congenital* form is so rare as to be clinically unimportant. Acute bronchiolectasis in children may follow whooping-cough and resemble suppurative bronchial pneumonia. The *chronic* is the usual form and results from foreign bodies in the bronchi, or an aneurysm or neoplasm pressing on the bronchi.

Symptoms.—Paroxysmal cough especially in the morning, and perhaps several times daily, which may be excited by change in position. The sputum is abundant, fetid, of sweetish odor, and separates into three layers: (1) Froth, (2) fluid, (3) heavy deposit containing Dittrich's plugs, leukocytes, and crystals. A slight hemoptysis often occurs, the general health is fair, although often there is pallor with some cyanosis. There is little or no fever.

Complications.—Sepsis, abscess of the brain, septic bronchial pneumonia, pleuritis, pericarditis, gangrene of the lung, recurrent attacks of bronchitis, arthritis, hypertrophic pulmonary osteo-arthropathy.

Treatment. A. *Prophylactic.*—As bronchiectasis may follow the aspiration of infected fluid during tonsillectomy or other operations about the mouth, the avoidance of deep general anesthesia and the substitution of a local anesthesia as far as possible, and the use of suction devises to prevent the aspiration of pharyngeal secretions into the trachea are important. Foreign bodies should early be localized and removed through a bronchoscope.

B. *Inhalations.*—In acute bronchiectasis, especially, the inhalation of steam impregnated with creosote, phenol, compound tincture of benzoin, menthol, eucalyptus, or turpentine, alone or in combination, reduces the fetor and gives a measure of relief.

C. *Postural Drainage.*—The patient assumes a position, such as hanging over the side of a bed for three to fifteen minutes several times a day, that will afford dependent drainage of the cavities.

D. *Bronchoscopic Treatment.*—The bronchoscope is introduced every seven to fourteen days, the cavities emptied by aspiration, irrigated by a mild antiseptic solution such as: Picric acid, 2 grains; Lugol's solution, 7 drops; saline solution to make 1 pint (Jackson). The cavity may then be insufflated with bismuth subcarbonate or subiodid of bismuth, or an oily instillation containing gomenol, iodin, or other antiseptic used.

E. The treatment should include *fresh air* and *sunshine*, overfeeding, and vaccines. As a percentage of the patients recover spontaneously, or under postural or bronchoscopic treatment, radical operation should not be considered during the early months of bronchiectasis.

F. *Operations* to produce collapse or compression of the affected lung. If the condition has persisted at least three months, and no improvement has followed the milder measures, the influence of compression or collapse of the lung should be tried.

1. Artificial pneumothorax should be used first and, if this gives improvement, it should be repeated every ten days or two weeks. If adhesions prevent the production of pneumothorax, a thoracotomy may be done and adhesions separated, or compression of the affected portion of the lung produced by extrapleural packing, or by collapsing the overlying rigid thorax.

2. Graded extrapleural thoracoplasty is performed in stages. This is the safest radical operation.

For a process located in the lower portion of the lung, the operation follows the method of Wilms, in the resection of 8 to 10 cm. posteriorly of the third or fourth to the eleventh ribs, inclusive. This part of the operation is done in two or three stages, under local anesthesia combined with a light nitrous oxid-oxygen or ethylene analgesia, or a light narcotic anesthesia. On completing the resection, the intercostal nerve-trunks may be blocked by injecting a few drops of 95 per cent. alcohol. The resection is continued in stages through an anterior incision parallel with and outside of the

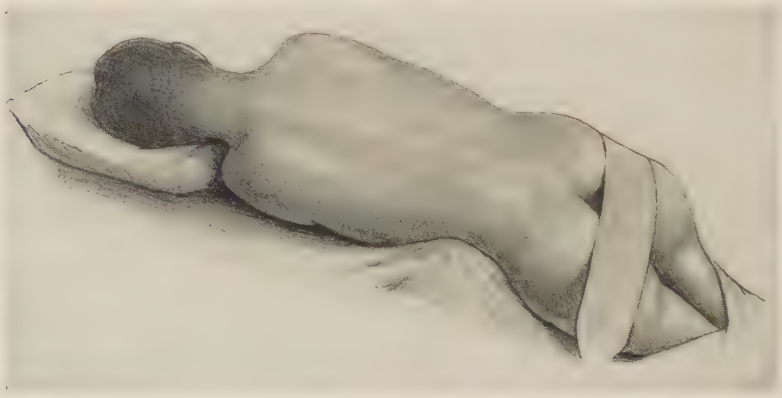


Fig. 726.—Position of the patient with elevation of the thorax for operation upon the lung.

costochondral junctions, the remaining section of ribs being removed anteriorly external to the cartilage. The incisions are immediately closed, with a small drain for twenty-four or forty-eight hours. Not over one-half hour should be taken by each step. By using six to ten steps, Hedblom has obtained excellent results with a very low mortality.

3. Bronchostomy: A permanent bronchostomic fistula through the skin drains and aërates dilated bronchi, reduces the anaërobic growth and the associated odor. The mortality of the operation is about 25 per cent. The fistula is permanent, the patient breathing partially through the larynx and partially through the new opening. The improvement, which is partial, depends upon the extent and position of the disease and the placement of the fistula. Only rarely is the operation advisable. Asphyxia may follow the entrance of water into the fistula during bathing.

4. Apiotomy—collapse of the apex of the lung—by resection of the upper ribs, or a free extrapleural transplant of fat or other tissue, is useful in the rarer forms of bronchiectasis or cavitation involving the upper lobe.

5. Pneumectomy is a dangerous procedure, to be used only in chronic cases and when milder measures have failed. Excision of the apex of a lung for apical tuberculosis has lost favor, due to excellent results from non-operative measures. A *cautery pneumectomy* (Graham) has the advantage of relative safety, with a mortality of about 10 per cent.

The affected portion of the lung is exposed by turning up a large flap of the entire thickness of the chest wall; the lung, if not adherent, is sutured about the opening, and a gauze packing applied. At the second stage an ordinary soldering iron, heated to a dull red heat, is made to burn into the center of the bronchiectatic area. As the lung is insensitive, this may be done without anesthesia or with a light nitrous oxid-oxygen narcosis. If necessary, almost an entire lung may be destroyed. The eschar comes away in about ten days and, owing to the low pressure (25 mm. of Hg) in the pulmonary arteries, secondary hemorrhage is rare. Where the bronchiectatic area is limited, complete relief has followed this operation.

Fig. 727.—Head-dependent position for operation upon the lung or bronchi with infection in the upper part of the lung.

6. Lobectomy: Where a lobe of the lung has been transformed into dense fibrous tissue, with multiple, undrainable, bronchial dilatations which only occurs after the disease has lasted a year or more, surgical removal of the lobe may be practised.

The patient should be under thirty-five years of age, and in a condition to withstand a very severe operative procedure. For greater safety the operation may be done in stages, the involved lobe of the lung being exposed by a major thoracotomy incision, adhesions separated, the pedicle ligated in sections, and the lobe excised with drainage. Not more than three-quarters of an hour should be consumed for each stage, and the operation should be deferred if the pulse becomes irregular, if a marked fall in blood-pressure occurs, or if there is severe hemorrhage (Lilienthal).

An operative mortality of about 50 per cent. has prevented the more general adoption of lobectomy.

Cerebral Air-embolism ("Pleural Shock").—From the negative pressure in the thorax, during inspiration air may enter an open pulmonary vein and

be carried to the brain. This is much more serious than pulmonary air-embolism, which follows the entrance of air into the systemic veins.

Etiology.—The air may (1) be injected into the pulmonary vein or dilated veins of the parietal pleura; or (2) be aspirated into the vein; or (3) pass directly from the left to the right heart through a patent foramen ovale.

Cerebral embolism may occur in irrigating a wound of the lung or pleura, on the injection of paste or oil into an empyema cavity, from an exploratory needle puncture of the hilum of the lung, from pneumotomy for pulmonary gangrene of the lung, and the like.

Symptoms occur during operations upon the lung or pleura from the entrance of even 2 or 3 c.c. of air into the pulmonary veins, and vary from a transient collapse with headache, blindness and dizziness, to immediate coma and death. There is pain, pallor, nausea, dilated pupils, collapse, dyspnea, stertor, weak pulse, tonic or clonic convulsions, manic depressive symptoms, retrograde amnesia, coma, transient or permanent blindness, and mottling of the skin. These symptoms were formerly thought to be due to a pleural reflex. The accident more frequently happens when induration of the lung prevents the collapse of the veins (Schlaepfer).

Diagnosis may be confirmed by observing bubbles of air in the arteries of the retina by the ophthalmoscope.

Treatment.—The head should be lowered, the injection or other manipulation suspended, the air permitted to escape from the thoracic cavity and, if there is marked depression of the circulation, intravenous or intracardiac injections of epinephrin should be made. With the cessation of respiration artificial respiration should be started, preferably by mouth-to-mouth insufflation, to prevent the aspiration of more air.

Embolism from the Injection of Paste.—From the injection of bismuth and other pastes into the pleura, multiple emboli may lodge in the brain, intestines, and other parts and be fatal, or the patient may recover with secondary blindness, paralysis, or other evidence of the local arrest of the circulation.

Cerebral symptoms are usually permanent, instead of transient as in the case of air-embolism. Great care should be taken, in the injection of paste, that air is not imprisoned in the pleural cavity under pressure.

Bronchial Fistula.—(1) The most common is the *bronchopleural* fistula, occurring as a complication of pulmonary tuberculosis with a tuberculous pyopneumothorax, and usually not amenable to surgical treatment. Bronchopleural fistula also frequently occurs in the course of non-tuberculous empyema, and generally closes spontaneously as the empyema-cavity is healed. Irrigation or the injection of liquids into the pleural cavity, if there is a fistula, is dangerous, causing violent cough, suffocation, and dyspnea. (2) *Bronchocutaneous fistula* occurs from abscesses and gangrene of the lung. Operative measures should be delayed until pus is eliminated, the gangrenous tissue expelled, and the cavity presents a clean granulating surface.

Treatment.—(1) Cauterization. (2) Liberation and excision of the fistulous tract by sharp dissection, and closure of the opening in the bronchus by a purse-string suture introduced in peribronchial connective tissue. (3) Transplantation of sufficient fat and fascia in the aseptic extrapleural space to fill the

defect in the lung, the transplant being carefully covered by living tissue. (4) A plastic operation upon the chest wall, with the transference of a pedicled flap (made up of skin, fascia, and muscle) into the defect.

Pulmonary Tuberculosis.—Varieties.—Tuberculosis of the lungs may be divided into: 1. *Miliary tuberculosis*, which is inoperable.

2. *Acute tuberculosis* or *caseous pneumonia* (*acute pneumonic phthisis*, *caseous* or *epithelial pneumonia*) characterized by the massive consolidation of a lobe of the lung, which later melts down, floods the bronchial tree with tuberculous material, and usually is fatal in three or four months from diffusion with enteritis, laryngitis, asthenia. It often occurs in robust males, is rare in childhood, resembles pneumonia, but is without crisis or resolution.

3. *Acute tuberculous bronchial pneumonia* (*galloping consumption*, *phthisis florida*) is characterized by multiple areas, rapid course, and death usually in eight to sixteen weeks. May occur from aspiration, as from a focus in the apex, or as a disseminated ulcerative type in those with lowered resistance from diabetes, alcoholism, pregnancy, measles, whooping-cough, or influenza. It is not operable.

4. *Subacute tuberculous bronchial pneumonia* smolders on with remissions and exacerbations for many months or years.

5. *Chronic ulcerative tuberculosis*, characterized by cavity formation and induration, usually at apex, with long periods of quiescence and recurrent acute exacerbations.

6. *Fibroid Phthisis:* A very chronic type, with the formation of much fibroconnective tissue, and contraction, which may continue twenty years. It is seen in coal-miners and others exposed to irritation from the inhalation of mineral dust, and is occasionally associated with bronchiectasis.

Surgical Treatment.—In miliary tuberculosis and acute tuberculous bronchopneumonia the condition is hopeless and operation is not to be considered. In acute tuberculous pneumonia in a young and fairly robust patient, the early removal of the affected lobe of the lung may be considered, as a means of preventing the secondary liquefaction and usually fatal dissemination of the disease. But few operations have been attempted for caseous pneumonia. After pneumectomy in which almost the entire lung was removed, Macewen's patient was alive sixteen years later, and in good health with, of course, marked deformity of the chest. In the other forms of tuberculosis, especially those with cavitation, artificial pneumothorax or collapsing operations by forms of thoracoplasty are at times helpful.

Tuberculous hydrothorax or *empyema*, as a rule, contraindicates an open operation, and the condition is to be treated by aspiration and possible injection of the pleural cavity, together with heliotherapy and other roborant measures. In mixed infection, unfortunately, thoracostomy is necessary, and may leave a persistent sinus.

Echinococcus (Hydatid) Cysts of the Lung.—Symptoms may be absent until the cyst perforates or becomes infected, or bronchial obstruction takes place. Cough and hematemesis are common, cavitation, pleurisy, empyema may occur. Fluid containing hooklets and small cysts may be expectorated. Eosinophilia is very suggestive, and a complement-fixation test diagnostic.

The roentgenogram shows the rounded, sharply outlined wall of the cyst, with calcification, if this has occurred. Needle-puncture should not be used for fear of disseminating the parasites.

Prognosis.—Occasionally spontaneous evacuation and recovery occur. Operation is followed by recovery in 90 per cent.

A two-stage operation, as a rule, is preferable, the lung being first fixed to the chest wall over the area of the cyst, and at the second operation the cyst cautiously injected with a 2 per cent. iodin or 1 per cent. formalin solution, then evacuated or marsupialized. Suppurating cysts may be treated in the same manner.

Tumors of the Lung.—Benign tumors are rare. *Fibromata* are usually small, 2 to 3 cm. in diameter, multiple, situated about the bronchi or in the peribronchial connective tissue. *Lipomata* occur as minute subpleural tumors. *Lymphomata* have been found in large numbers in the lung in association with a general lymphomatosis. *Enchondromata* form rounded irregular masses, from 4 to 6 cm. in diameter, springing from the cartilage of the bronchi, usually near the hilum. Rarely, *osteomata* develop in the interlobular tissue. These tumors are seldom of clinical importance, and rarely require operation.

Malignant Tumors.—Primary malignant tumors are rare. *Carcinoma* is the most common. It develops unilaterally at a relatively early age, gives rather late metastasis, is three times as frequent in men as in women, chiefly involves the right lung, is often associated with tuberculosis, and usually starts in a bronchus forming: (1) A nodular circumscribed tumor, easily recognized through the bronchoscope; or (2) a diffusely infiltrating growth. *Symptoms* include cough, bloody sputum, fever, loss of weight, fatigue, and dyspnea, pain in the chest radiating to the upper abdomen, amphoric or bronchial breathing, and râles. Roentgenogram suggests a pulmonary abscess. With disintegration and expulsion of the central mass, a cavity or cancer cavern is formed.

In the bronchi, *adenocarcinoma* develops from the glands of the submucosa or, more rarely, from squamous epithelium. From obstruction of a main bronchus, partial or complete atelectasis may occur, with the retraction of the chest wall and deficient inspiratory sounds. The sputum is often blood-stained, and may contain bits of carcinoma. A diffuse alveolar carcinoma spreading through several lobes is, of course, ineradicable.

Primary sarcoma and *endothelioma of the lung* are exceedingly rare. In Germany, lymphosarcoma of the bronchial glands and peribronchial tissues became endemic among workers of the Schneeberg mine, apparently from the inhalation of arsenical dust. *Symptoms* include cough, loud stridor, enlargement of the mammary veins, and other evidence of compression of bronchi.

Roentgen Diagnosis of Malignant Disease of the Lung.—The opacity of a primary carcinoma of the lung may be recognized early by a Roentgen examination. The more common infiltrating type begins at the root of the lung, and gradually infiltrates the entire organ. The nodular type either begins in the hilum or in the parenchyma of the lung, forming sharply defined and irregularly outlined masses. In sarcoma, the growth is apt to extend outward along the septum between the upper and the middle lobes on the left side, or about the middle lobe on the right side (Pfahler). Secondary metastatic carcinoma

develops in nodules generally distributed in the parenchyma of the lung, from a few millimeters to 3 cm. in diameter, neither very dense nor sharply outlined. Metastatic sarcomas are denser and more sharply outlined.

A secondary infiltrating tumor may begin at the hilum or in the mediastinum, with general thickening and infiltration. Miliary nodules throughout the lung occur, closely suggesting miliary tuberculosis, but are larger, denser, more sharply outlined than those of tuberculosis. About one-third of the advanced cancers of the breast are associated with secondary growths in the lung.

Treatment.—Two successful radical operations for carcinoma of the lung have been reported from Sauerbruch's clinic. In one, a circumscribed cancer of the right lower lobe, involving the diaphragm, was removed by resecting the lung and the attached diaphragm. In the second, a carcinoma the size of a small fist was removed from the left lower lobe of a woman. The first patient was alive three years, the second patient five years after the operation.

It is advisable to do the operation in two stages, first making a rib resection and ligating the pulmonary artery, and three or four weeks later resecting the lung and contained tumor. The lung overlying the growth also may be attached to the chest wall at the first operation, and the tumor destroyed by cautery or electrocoagulation at the second stage.

Radium Treatment.—Bronchial growths may be treated by the application of radium, or by the introduction of radium seeds through the bronchoscope. A severe local reaction follows. For other growths in the lung, *cross firing* by 100 mg. of screened radium (1 cm. of lead and 1 cm. of wood) at ten to sixteen positions, for a total of 1200 to 2900 millicurie hours, may be tried. The treatment should be considered only as palliative.

Secondary tumors frequently involve the lung, the pulmonary capillaries arresting malignant emboli, especially of sarcoma. Carcinoma of the mammary gland, chorio-epithelioma, hypernephroma (invades the renal vein), carcinoma of the stomach, intestines, pancreas, suprarenal, and thyroid metastasize to the lung.

Symptoms include cough, dyspnea, "prune-juice" or bloody expectoration, bloody pleural effusion, enlargement of the mediastinal lymph-nodes, pressure with dilatation of the veins of the neck, thorax, and head; edema, dysphagia, and unequal pupils. Later there is progressive emaciation, cachexia, and moderate pyrexia.

Treatment.—Secondary malignant growths are hopeless. Palliative treatment including radiation may be used.

Surgical Diseases of the Mediastinum.—The anterior or posterior mediastinum, or both, may be involved. The anterior mediastinum contains the thymus, the ascending aorta, the superior vena cava, the innominate vein, the phrenic nerve. The posterior mediastinum—the descending aorta, the azygos vein, the thoracic duct, the vagus, the sympathetic nerves, and the esophagus.

Acute mediastinitis may follow: 1. *Thoracic injury* (a) without an open wound, as from a blow or crush; or (b) from an open wound, as a stab, sword, or gunshot wound.

2. *Extension of an inflammatory process* from the neck: (a) Along the carotid

or jugular vessels; (b) the fascial planes in front of the larynx or trachea; (c) behind the pharynx or esophagus, or the prevertebral space.

3. *In the thorax*, from: (a) Perforation or ulceration of the esophagus, as in carcinoma; (b) spinal caries; (c) infection and abscess formation of the mediastinal lymph-nodes; (d) inflammation spreading from the ribs, sternum, and lungs.

Over two-thirds of the cases involve the anterior mediastinum, about one-third the posterior, a small percentage both the anterior and posterior. Acute mediastinal emphysema may follow pneumectomy and retraction of an open divided bronchus into mediastinum.

Symptoms.—Pain behind the sternum, radiating to the shoulder-blades or spine. The sternum may be sensitive on pressure or percussion, and there may be throbbing pain from the action of the heart. Fever, chills, sweating, dyspnea, irregular heart-action occur. The abscess may rupture by the side of the sternum, through an intercostal space, into the trachea, esophagus, pericardium, or pleural cavity.

Diagnosis depends upon pre-existing disease or injury of the neck, esophagus, trachea, vertebral column, sternum, or ribs, with local evidence of inflammation. The condition is very dangerous.

Treatment.—For the anterior mediastinum incision and drainage are made, either through a trephine opening in the sternum, or by resection of the overlying costal cartilages and ribs with portions of the sternum.

From the posterior mediastinum the abscess may point in the supraclavicular fossa. If the abscess has not pointed, *posterior mediastinotomy* may be done, by resecting the transverse processes and adjoining portions of ribs that overlie the cavity. The approach should usually be through the right side, unless the signs and exploratory puncture indicate that the pus is upon the left.

Mediastinal Lymphadenitis.—*Tuberculous:* Tuberculous enlargement of the mediastinal lymph-glands is common, and may or may not be associated with tuberculosis of the lung or cervical nodes.

Acute lymphadenitis occurs as an acute febrile condition of children, and in inflammations of the lung. Slight unilateral changes in children, with spasmodic cough (Eustace Smith), venous hum heard at the root of the neck only when the head is thrown back, may be due to pressure of the nodes on the large veins.

Suppurative lymphadenitis follows simple or tuberculous adenitis, and gives rise to mediastinal abscess and its symptoms.

Indurative Mediastinopericarditis.—Chronic fibrosis of the mediastinal tissues from tuberculosis or other cause is rare. It usually begins in youth and progresses slowly. It produces cardiac hypertrophy, dyspnea, cyanosis, cardiac failure.

Treatment.—Where the pericardium is so well fixed or bound down as to cause embarrassment, the overlying bony and cartilaginous chest wall should be resected.

Dermoid cyst of the mediastinum is rare; only 118 cases have been reported (Beye). It is found in both sexes, usually between the ages of fifteen and thirty.

Pathology.—There is a unilocular globular mass, from the size of a hen's egg to one filling the chest, which displaces adjacent structures or, rarely, is embedded in the lung substance. The dermoid is probably derived from the third branchial arch, which produces a deep sinus in the formation of the thymus. If the lower mediastinum is involved there may be imperfect closure of the anterior thoracic wall.

Symptoms.—Cough and occasionally hemoptysis and the presence of hair and pultaceous dermoid material in the sputum, from rupture into a bronchus. Dyspnea may become extreme, with dysphagia, substernal pressure, or sharp, stabbing pain. Occasionally the symptomatic onset is acute, suggesting pneumonia, empyema, or pleurisy with effusion. A swelling may appear above the sternum, behind the clavicle, or produce a diffuse bulging of the chest wall on the affected side, as it approaches the surface above the sternum and clavicle. It has a boggy consistence, and may pulsate from underlying vessels. Although usually found on one side of the upper thorax, the dermoid may rest upon the diaphragm.

The roentgenogram shows a spherical shadow without expansible pulsation, surrounded by normal lung. Calcification or bone-shadows may be present.

Diagnosis should be made from aneurysm, pleural and pulmonary infection.

Treatment is thoracotomy and enucleation, which gives a mortality of 22 per cent. The operation may be done in two stages, with primary partial evacuation or marsupialization.

Tumors of the Mediastinum.—*Primary tumors* usually are malignant and originate chiefly in the bronchial glands or thymus. Lymphosarcoma grows rapidly and carcinoma infiltrates important adjacent structures.

Symptoms.—Dulness over the sternum on percussion, deformity, edema, venous engorgement, enlargement of the cervical glands, and marked dyspnea occur with tumors of the anterior mediastinum.

Pressure-symptoms often develop early, with bulging of the ribs, clavicle or sternum, the development of a mass in the supraclavicular fossa, and enlargement of the veins of the neck and chest. The trachea may be displaced, and enlarging lymph-nodes in the neck and axilla aid in the diagnosis.

In the posterior mediastinum the tumors usually originate in the lymphatic glands, the symptoms being marked but the signs obscure. Ringing cough, dysphagia, dyspnea on inspiration, stridor, evidence of pressure upon the recurrent nerve and vagus, and enlargement of the veins of the neck and chest occur with both posterior and anterior growths.

Diagnosis from thoracic aneurysm, syphilis, and tuberculosis may be difficult, but cyanosis and venous enlargement with pleural effusion are more common in tumors, and *x*-ray study is valuable.

Treatment.—Enucleation is rarely feasible. Palliative treatment with radiation may retard the progress of the growth.

Operations on the Lung.—A. *Operations*, objectionable, inefficient, or rarely used: (1) Injection of drugs into lung through the chest wall (Pepper). (2) Artificial hydrothorax to collapse and immobilize the lung. (3) Enlargement of upper costal ring by resecting first rib (Freund's operation). (4) Ligation of branches of pulmonary artery to produce fibrosis and contraction of a part of lung. (5) Local thoracoplasty (Quincke) is used for cardiolysis and pulmonary cavities. (6) Major one-

stage thoracoplasty (Friedrich-Brauer) has a high mortality. (7) Pneumectomy for tuberculosis or tuberculous cavities. A one-stage partial pneumectomy has a high mortality.

B. *Operations* at present chiefly used: (1) Artificial pneumothorax for tuberculous pulmonary cavities, pulmonary hemorrhage. (2) Graded extrapleural thoracoplasty for bronchiectasis, chronic pulmonary abscess, tuberculosis, and tuberculous cavities. (3) Phrenicotomy to paralyze one-half of the diaphragm, to increase the effect of thoracoplasty. (4) Pneumotomy (including Wilms' operation) in one or more stages, for gangrene, abscess, bronchiectasis, hydatid cyst. (5) Graded pneumectomy or cautery pneumectomy, for resistant forms of bronchiectasis, abscess, tumor.

The parietal pleura is sensitive; the visceral and diaphragmatic pleura and parenchyma of lung insensitive to pain. The pulmonary vessels are insensitive and probably without vasomotor nerves. A marked reflex (vagus) may follow ligation of the proximal arteries, or traction on the root of the lungs. The pulmonary arteries with their low blood-pressure (25 mm. Hg) are easily controlled.

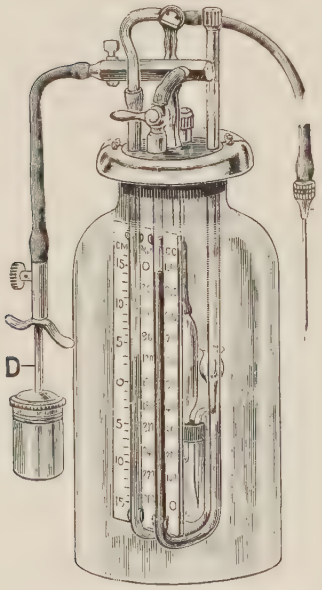


Fig. 728.—Loving's pressure pneumothorax apparatus. Air filtered through phenol solution and cotton is forced by the pump *D* through the apparatus, the delivery of air into the chest in cubic centimeters and the intrathoracic pressure being shown by the scales.

Mass-ligation of the hilum should be avoided, and the large bronchi carefully curetted of mucosa and occluded, to prevent retraction, air-fistula, and mediastinal emphysema.

Artificial Pneumothorax (Forlanini, 1882; Murphy, 1887).—Nitrogen gas introduced through a fine needle into the pleural cavity, causing collapse of the lung: (1) May occlude lymph-channels; (2) arrest or prevent hemorrhage, and (3) favor compression and fibrous-tissue contraction, and the collapse of pulmonary cavities with sufficiently mobile walls. When the intrapleural pressure runs from 0 to 3 mm. Hg there is absolute pneumothorax, −3 to −5 mm. Hg gives relative pneumothorax, −6 to −9 mm. Hg gives the inspiratory maximum and, if the pressure is reduced below this in the pleural cavity, there is tendency to overdistention of the lungs. A negative pressure of −5 to −6 mm. Hg is preferred in open pneumothorax. By pneumothorax in tuberculosis the lung is put at rest, the secretion and expectoration is decreased, the temperature is reduced, and there is less tendency for dissemination and the formation of fresh foci. The pneumothorax is continued by the repeated injections of nitrogen for from several months to several years. Even though the lung has been compressed for from two to seven years, on discontinuing the treatment it expands and so perfectly resumes its function that a pneumothorax of the other side may be produced later. Under compression, the circulation of blood through the lung is reduced, the lymph-flow is slowed, and connective tissue is produced more completely and abundantly about caseous foci.

Indications.—(1) Severe chronic infection of the lung, the other lung being free or almost free from disease, with absence of adhesions on the affected side. (2) Possibly in severe disease of one side with adhesions, the disease being absent or limited on the other. The adhesions are detached by repeated compressions. (3) Severe hemorrhage with unilateral disease without adhesions.

Artificial pneumothorax is *contraindicated* while there is: (1) Extensive bilateral disease with a tendency to liquefaction on both sides, and nearly universal adhesions on the affected side. (2) Serious disease, tuberculous or otherwise, of other important organs. (3) Acute infection of the opposite lung.

Results.—About 50 per cent. of the patients show marked improvement.

Technic.—For artificial pneumothorax the patient is placed in a semirecumbent position, and the injection made slowly in the fifth, sixth, or seventh intercostal space along the anterior axillary line. It is desirable to first puncture the skin and intercostal muscles, and then force a blunt-pointed cannula through this puncture into the pleura. Fluctuations in an attached manometer show that the pleura has been entered.

In the first injection ½ to 1 liter of nitrogen is introduced, the lung being partially collapsed. A sharp needle may be used for later injections. The second injection is given one or two days later, and the later injections given at intervals of possibly two, three, or four weeks or longer, as the absorptive capacity of the pleura decreases. Fifteen to twenty injections are usually required, and from 300 to 1000 c.c. of nitrogen are introduced each time. The pressure should be maintained at about zero on inspiration, and 3 to 6 mm. Hg on expiration.

Pneumolysis.—(1) *Local Thoracoplasty (Quincke's Operation)*: The rigid portion of the thoracic wall is resected over the area of disease, to produce pressure upon the affected portion of lung and secondary shrinking and absorption. Used over pulmonary cavities, the operation may not succeed on account of insufficient sinking in the chest wall. (2) *Pneumolysis of Friedrich* and *Brauer* is used for extensive disease, largely limited to one lung, that is progressing in spite of medical and hygienic treatment in a patient with a fair general condition.

Technic. A large U-shaped incision is made like that for the Schede operation, the flap containing the skin, the scapula, and muscles down to the ribs; the ribs are resected subperiosteally, from the second to the tenth, inclusive, and from the neck to the cartilaginous attachment. The ribs are removed by being twisted away from their posterior attachments. Finally the intercostal muscles are removed from the pleura, hemorrhage controlled, and the incision closed. As the mortality of this extensive operation is about 30 per cent. when done at one stage, it has been replaced by the multiple-stage operation, the ribs being resected in from three to ten operations.

Wilms' operation (1911) consists in reducing the capacity of the thorax by resecting segments of the ribs posteriorly, and also corresponding portions of the costal cartilages anteriorly.

Technic.—Local anesthesia is used, and the first vertical incision made parallel with the spine, over the angles of the ribs from the first downward. The fibers of the trapezius and rhomboidei are separated, retracted, and 4 cm. of the first, second, and third ribs resected subperiosteally. The fibers of the muscles are then separated over the fifth rib, and the resection continued with the fifth and sixth ribs; another muscular separation is made over the seventh rib, and such number of the lower ribs resected to permit sufficient collapse of the chest. The second incision is made parallel with and ½ cm. from the sternum, and the corresponding portions of the costal cartilages resected subperiosteally.

The wounds are closed, the side well strapped, and the patient placed on the affected side. This operation has been modified by Sauerbruch, Hedblom, and others, by dividing the operation into stages and resecting much larger segments of the ribs. By resecting portions of the tenth and eleventh ribs, the diaphragm may be relaxed and mobilized, and the lung deprived of much of its inspiratory power.

Lipotamponade.—To compress the apex of the lung in tuberculosis, Tuffier suggested an incision through the second intercostal space, the separation of unopened pleura corresponding to the apex of the endothoracic fascia, and the filling of the large extrapleural cavity thus formed with a mass of free fat; the intercostal and skin wounds being carefully closed. Although improvement has been reported following the operation, it has had very limited use.

Costal pseudarthrosis (*Freund's operation*) has been used for both pulmonary emphysema and apical phthisis. Freund considers the impeded development of the first costal cartilage and the associated stenosis of the upper aperture of the thorax to so influence the structure and function of the apex of the lung as to render it susceptible to tuberculosis.

Technic.—A vertical incision with a slight mesial curve is made over the outer portions of the costal cartilages, from the second to the sixth. The ribs and costal cartilages are exposed for from $1\frac{1}{2}$ to $2\frac{1}{2}$ cm. at their junction. An excision of from 3 to 5 cm. of each rib and cartilage, from the second to the sixth rib, is made. The corresponding portions of periosteum and perichondrium are removed to prevent regeneration, and if there is apical phthisis the first rib is also removed.

Indications for the operation (Douay and Delbet): (1) Emphysema with dilation of the thorax and diaphragmatic embarrassment. (2) Emphysema with partial thoracic rigidity, due to sternochondral ankylosis. (3) Emphysema with circulatory disturbances and cyanosis, due to dilatation of the heart, especially auricular, with or without thoracic dilatation or rigidity. (4) Apical tuberculosis (Freund).

Phrenicotomy (*division of the phrenic nerve; phrenic exeresis; phrenic avulsion*—Thiersch) paralyzes one-half of the diaphragm, limiting respiratory movement, and reducing the capacity of the corresponding half of the thorax. The nerve also may be blocked in the neck by the injection of alcohol, or temporarily paralyzed by exposure and freezing with ethyl chlorid.

Technic.—These operations may be performed under local anesthesia, with or without a moderate narcotism. An oblique incision is made along the lateral border of the sternomastoid, 5 cm. long, beginning 2 or 3 cm. above the clavicle. The skin, platysma, and fascia are divided at the lateral border of the sternomastoid, the muscle retracted mesially, the omohyoid downward and laterally; the fat, glands, and deep cervical fascia penetrated to the scalenus anterior muscle, which is crossed obliquely from above downward and mesially by the phrenic nerve. The internal jugular vein is drawn to the side. Pinching the nerve dilates the corresponding pupil. The nerve is divided, resected, injected, or avulsed by slowly winding the peripheral end upon a hemostat until the branches give way. Care should be taken to avoid the vagus, avulsion of which may be fatal.

These operations may be used to increase the effect of a compression operation or for spasm of the diaphragm.

Ligation of branches of the pulmonary artery has been used to cause induration, fibrosis, and contraction of the corresponding portion of the lung (Sauerbruch), the branches going to the left lower and the right upper lobe, being especially suitable for ligation.

Technic.—For the left lower lobe the patient is placed on the back, with a pillow back of the thorax and the left arm pulled upward, outward, and backward. A long incision is made through the fifth intercostal space, the ribs spread, the upper and lower lobes separated, exposing the pedicle of the lower lobe, in which are the pulmonary artery, vein, and bronchus; the artery being most superficial, and the bronchus lying between the vein and the artery. The ligature is passed from between the bronchus and the artery.

On account of the operative difficulties, Lilienthal has suggested the ligation of the pulmonary artery from within the pericardium. None of the methods has come into general use.

CHAPTER XLVI

THE HEART AND AORTA

Congenital Anomalies.—Defects of the overlying thoracic wall occur with protrusion of the heart. In such a case, where the apex of the heart protruded through a defect in the left upper part of the sternum and overlying skin, Kirmisson replaced the heart and closed the gap by a large skin flap, the patient recovering without symptoms from the absence of the pericardium.

Mobile, movable, or *wandering heart,* with serious symptoms produced by change in posture, may be treated (1) by affixing the pericardium to the overlying chest wall by sutures, (2) by using strips of pericardium for suspensio or (3) by supporting the heart by a transplantation of masses of fat.

Persistent ductus arteriosus may be subject to occlusion by ligation.

Heart-failure.—*Functional tests* of cardiac weakness are based on: (1) Response to exercise, especially stair-climbing. (2) Narrowing of the pulse pressure. (3) Pulsus alternans as shown by the sphygmomanometer. The electrocardiograph gives only presumptive evidence of impending failure. The determination of vital capacity has a certain quantitative value.

Acute heart-failure is shown by rapid dilatation of the heart, engorgement of the veins, and congestive phenomena. It may, however, occur without these signs, with enfeeblement and even the slowing of heart-beats.

Wounds of the heart involve the right and left ventricles about equally, the auricles in only 7 per cent. of the cases. Wounds of the thin-walled auricles are more dangerous from hemorrhage than those of the ventricles; of the right ventricle more than the left ventricle, because the greater thickness of walls and greater size of the columnæ carneæ of the left ventricle favor thrombus formation. Wounds of the interventricular septum are not as dangerous as those that open the cavities; provided the coronary arteries are not divided. Division of the larger branches of the coronary artery produce, although not invariably, myocardial degeneration. Wounds of the auriculoventricular septum, involving the bundle of His, may be instantly fatal. Gunshot wounds are more dangerous than incised wounds; needle punctures much less serious than stab wounds. Bullets and other foreign bodies may remain embedded in the pericardium or myocardium for years. In Picque's case the bullet remained encysted in the pericardium fifty-two years.

Symptoms.—Marked hemorrhage after a penetrating wound of the chest indicates injury of the internal mammary artery, the heart, great vessels, or the lung. Rarely serious hemorrhage occurs from a wound of the pericardium alone. From a wound of the heart the symptoms vary from instant death to disability so slight that the patient continues to walk about, ultimately recovering, or dying after hours or days, with the pericardium and possibly the pleura filled with blood. Two hundred and fifty cubic centimeters of fluid accumulat-

ing in the pericardial sac within thirty minutes will prevent the heart beating (Beck). Gradual effusions, as in *Pick's disease*, may be much larger.

Symptoms include precordial anguish, pallor, shock, marked dyspnea, rapid shallow respirations, cyanosis, fall in blood-pressure; weak, rapid, irregular or imperceptible pulse, collapse, and at times unconsciousness. The patient may show great restlessness and anxiety, develop convulsions, repeated vomiting, involuntary dejections, or, from an associated wound of the lung, hemoptysis. Locally there may or may not be hemorrhage from the wound. External bleeding is often insignificant.

Hemopericardium is suggested by increased area of cardiac dulness, soft, distant heart-sounds, venous distention of the neck, cyanosis, blueness of the lips, marked dyspnea, and a sensation of fear and suffocation.

Hematothorax: The left lung and pleura also may be wounded, and the blood may rapidly fill the thoracic cavity. The apex-beat often cannot be felt, there may be free fluid, or free fluid and air in the pleural cavity. The heart-sounds may be clear, altered, or imperceptible. The heart-action is often intermittent or irregular and splashing, blowing, or metallic ringing sounds may be heard. The symptoms may improve for a time to recur with increased severity or with sudden death from a return of the hemorrhage.

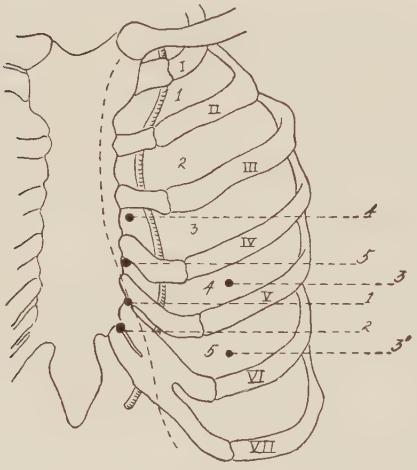


Fig. 729.—Different points for puncturing the pericardium: 1, Baizeau; 2, Delorme and Mignon; 3, Dieulafoy; 4, Schuh; 5, Trousseau. (Terrier.)

After recovery — weakness, vertigo, and irritability may persist for weeks or months, or pyopericardium, pericardial adhesion; hypertrophy, softening, and aneurysm and dilatation of the ventricular walls, or endocardial disease may follow.

The **diagnosis** may be difficult. In 7 of Stewart's cases no injury was found on exposing the heart.

Prognosis.—Recovery follows in about 8 per cent. of unsutured heart-wounds, and about $2\frac{1}{2}$ per cent. of unsutured gunshot wounds of the heart. About 50 per cent. recover after suture. The patient may die of hemorrhage into the pericardium, pleura, or rarely, externally; frequently death results from compression of the heart by effused blood in the pericardium (*pericardial* or *heart tamponade*), from secondary pyopericardium or other form of sepsis, or from secondary degeneration or rupture of the heart.

Treatment.—(1) *Aspiration* of the pericardium to relieve the pressure upon the heart may prolong life until the heart can be exposed and sutured. (2) *Cardiorrhaphy*, a quadrilateral flap is made, including the fourth, fifth, and sixth ribs and cartilages, hinged on the lateral side. The costal cartilages are divided close to the sternum, the flap turned outward by cutting or breaking the ribs at the lateral margin of the flap. The pericardium is opened, clots re-

moved, and the wound in the heart closed by interrupted fine silk sutures, care being taken to avoid the coronary vessels. During suturing, the heart may be fixed by one or two supporting sutures. The pericardium should not be completely closed, and the external wound is, as a rule, sutured without drainage. Secondary pyopericardium or pyothorax, requiring drainage, is not unusual.

Purulent pericarditis occurs in childhood and adults, the infection being by contiguity or through the blood. In children it usually follows acute exanthematous disease, or a septic process as osteomyelitis, otitis, or mastoid disease.

Etiology.—The pneumococcus, staphylococcus, streptococcus, Fränkel's diplococcus, Bacillus pyocyaneus, B. tuberculosis, B. coli communis, B. influenzæ, rarely the B. lactis aërogenes, or B. proteus vulgaris. Pneumococcic pus is thick and creamy; streptococcic, is abundant and thin.

Symptoms.—History of recent infection followed by fever of a septic type, with rapid pulse, dyspnea, restlessness, cough; precordial, epigastric, or abdominal pain; moderate effusion, palpitation. A proportionate increase in the frequency of respirations does not occur. With increasing effusion there is dyspnea, orthopnea, cyanosis, and rapid and irregular heart action, high fever and sweating, and loss of abdominal respiratory movements.

Diagnosis.—Exploratory puncture should be made 2 cm. from the edge of the sternum in the fifth interspace or in the sixth interspace.

Prognosis.—Mortality, 50 per cent. The outlook is best with free incision and drainage.

Treatment.—Resection of the fifth costal cartilage with dependent drainage.

Adhesive pericarditis (*cardiosymphysis, adhesive pericardiomediastinitis*) may be of the external or internal type. When advanced, the chest wall, heart, and mediastinum are bound together by fibrous tissue, which may even calcify, producing *concretio pericardii*. The fibrous tissue often invades the muscular wall of the heart, and the organ may be so bound and restricted as to be greatly hampered in its work. The descent of the diaphragm may be prevented, and respiratory movements limited.

Symptoms.—The secondary hypertrophy of the heart and the circulatory insufficiency are indicated by an increased area of cardiac dulness, great edema especially of the upper part of the body, enlargement of the liver, and ascites. In children, the syndrome of ascites, increase of the area of liver dulness, puffiness of the face, cyanosis of the face and ears, slight diminution of the pulse-rate, and nearly normal heart-sounds is almost pathognomonic. Invariably the increased area of cardiac dulness, systolic retraction about the apex, diastolic shock, and Broadbent's sign, or systolic retraction about the eleventh or twelfth rib posteriorly may be elicited. Systolic retraction of the lower costal and epigastric regions may be noted, with gallop rhythm, duplication of the second sound, paradoxical pulse, and respiratory swelling of the jugulars.

Treatment.—As it is difficult to separate the adherent pericardium without injury to the heart, the operation of *cardiolysis* (Brauer, 1902) is preferred. Under local anesthesia a flap of skin is raised, and such portions of the third, fourth, and fifth costal cartilages and ribs as overlie the enlarged heart are removed. To avoid injury to the pleura, the posterior layer of perichondrium

is left. The operative mortality is 5 per cent. Dyspnea, edema, pain, and hyperemia of the viscera are relieved by the operation.

Operations on the Valves and Orifices of the Heart.—Stenosis of the orifices may be improved by introducing a fine, hook-shaped knife through the aorta or ventricular wall, and incising the aortic valves or ring, as done by Cushing. Werelius successfully divulsed the mitral and tricuspid orifice by introducing and opening a hemostatic forceps.

Valvotomy is the operation of dividing the valve leaflets. For enlarging the mitral valve with a cutting punch, Cutler places a traction suture in the apex to steady the heart, while parallel mattress-sutures are placed in the wall of the left ventricle, crossed, the myocardium incised, and a *cardiovalvulotome* inserted. The puncture in the heart is closed by one or two Lembert's sutures; the mattress-sutures being pulled against each other, preventing all bleeding until this is accomplished. The operation has had very limited success.

Carrel has, by experiment, shown the feasibility of enlarging the valvular ring by sewing a quadrilateral patch of aponeurosis upon the outside of the heart, and dividing the valvular ring beneath the patch, one side of which is left unsutured until after the ring is divided.

Angina Pectoris.—Anginal pain originates in the heart and aorta, the impulses passing to the spinal cord with an overflow involving the somatic sensory neurons, producing the sensation of pain in the upper thorax, arms, and neck. Operative treatment was suggested by François Franck, 1899; the first operation was by Jonnesco, 1916. Operative treatment is used to give symptomatic relief by dividing the nervous arc. Efferent fibers from the heart include the depressor nerve of the vagus, and sympathetic fibers passing to the lower and middle cervical ganglion and first thoracic or stellate ganglion. Impulses producing anginal pain are carried only by the sympathetic fibers. The superior cervical sympathetic ganglion has a motor function, and need be attacked only when the pain radiates to the face and neck.

Varieties.—1. *Chronic* or *aortic type* (*aortalgia*) is due to spasm of the aorta; is characterized by repeated attacks of pain without objective signs, and usually is relieved by nitrites.

2. *Acute type* (Wenckebach), from coronary spasm or occlusion, is usually not relieved by nitrites; shows objective evidence of circulatory failure, with change in rate and power, and with pulmonary edema or other evidence of cardiac insufficiency.

The *first form* is excited by increase of blood-pressure and the volume of blood through the heart, and follows exertion, chilling, excitement, and overeating. The *second type* may occur during rest or sleep.

3. *Painless angina* (*angina sine dolore*).

Operative treatment is based upon: (1) *Interruption of sensory impulses* from the heart and aorta to the brain, by division of the second, third, and fourth thoracic sensory nerve-roots (Goodall and Earle, 1913), or by injection of the posterior roots by novocain followed by alcohol (Swetlow). (2) *Division of the depressor nerve* (Eppinger and Hoff), a part of the vagus difficult to locate or divide in man, which probably carries sensory fibers from aorta. (3) *Interruption of the sympathetic supply* relieves the aortic spasm, and may

consist of the removal of the cervical sympathetic ganglia and the upper thoracic ganglia (Jonnesco), or of only the superior cervical ganglion (Coffey, Brown, and Kerr).

Cervical Sympathectomy.—(a) Jonnesco's operation consists in the complete removal of the upper three cervical ganglia, and the first dorsal sympathetic ganglion on both sides. This is followed by complete relief or decided improvement in 8 per cent. of the cases, with a mortality of about 11 per cent. (b) Division or partial ablation of the cervical sympathetic chain has given almost equally good results, with a mortality of about 6 per cent. (c) The division of the sensory fibers entering and leaving the lower two cervical and the first dorsal ganglia, frequently gives relief, without removal of the ganglia. The superior cervical ganglion should be removed when there is radiation of pain to the face and neck.

Tumors of the heart include lipoma, myxoma, sarcoma, and carcinoma. The malignant tumors are usually secondary. Cysts occur, especially of the parasitic echinococcus type. Most of the tumors are myxomata, and the left heart is chiefly involved; secondary tumors more frequently involving the right heart. The tricuspid valve is often involved with irregular pressure-symptoms, including wasting, atrophy, and marked dyspnea, fainting attacks, arrhythmia, increased area of cardiac dulness, irregularities of the skiagraphic shadow, and peculiarities of the polygraphic tracing. A graphic record of esophageal pulsations is important.

Operative Technic. **Anesthesia:** Local anesthesia or paravertebral nerve-blocking is preferred for operations upon the heart. In certain cases intratracheal insufflation after the method of Meltzer-Auer is desirable to prevent pulmonary collapse. A preliminary injection of 0.01 grain of atropin to reduce the inhibitory action of vagus is desirable.

Paracentesis Pericardii.—For aspiration of the pericardium the needle is introduced in the fifth interspace close to the upper edge of the lower rib 3 cm. ($1\frac{1}{2}$ inches) lateral to the left sternal margin. The puncture also may be made in the right fifth interspace, close to the sternum. The internal mammary artery, the pleura, lungs, and heart should be avoided.

Pericardiotomy for pyopericardium is best made by an incision over the costoxiphoid angle with, if necessary, a resection of the seventh, or the seventh, eighth, and sixth left costal cartilages. One or two soft-rubber tubes are introduced to, but not into, the lower part of the pericardial cavity. Irrigation and antiseptics in the pericardium should be avoided. The mortality is about 22 per cent.

For tuberculous pericarditis pericardiotomy without drainage should be used.

Cardiac Resuscitation.—The contractions of the arrested heart may be restored by: 1. *Inversion of the patient,* so that the blood rushes into and suddenly distends the heart.

2. *Rhythmic compression* or *percussion* of the overlying chest wall. This is especially effective in children.

3. *Needling the heart,* or aspiration of the overdistended right ventricle. The operation is dangerous, especially if a large needle is used, or if the auricle is entered.

4. *Injections of drugs* into the cavities or walls of the heart. The injection of 1 to 20 minims of a 1 : 1000 solution of epinephrin by a fine needle, through the walls of the left ventricle, is very effective. The smallest effective dose should be used to prevent overstimulation of the heart.

5. *Electrical stimulation* of the heart, by an electrode introduced through the chest wall against the heart, is very efficient in lower animals but is rarely instantly available for human practice.

6. *Injection* into the blood-stream of warm aërated *physiologic saline,* Locke's or Ringer's solution, containing epinephrin. The apparatus consists of a simple funnel, a No. 16 hypodermic needle connected by 2 meters of rubber tubing. The funnel and tube are filled with the solution, the needle introduced into a convenient vein of the arm, leg, neck, a cranial sinus, or rarely, into an

artery; and as the liquid flows into the vessel, from 1 to 60 drops of a 1 : 1000 epinephrin solution are added, the flow being instantly arrested when the heart action is restored. Unless there is marked degeneration of the myocardium, 1 or 2 minims of epinephrin is an efficient dose, and 3 minims may cause such violent cardiac contraction as to shake the patient's body. To be effective the solution should enter the heart and the coronary arteries and, therefore, if the heart has already stopped beating, it is often necessary to combine the method with cardiac massage.

Cardiac massage (Schiff, 1874) enables the emptying of a dilated heart, the restoration of the coronary circulation and the cardiac rhythm, and the passage of stimulating substances from the circulation into the cavities of the heart and the coronary vessels.

1. *Subdiaphragmatic massage* is the most successful method. The hand, introduced through an abdominal incision, is carried above the left lobe of the liver, and the heart compressed through the diaphragm against the overlying chest wall, twenty to forty times a minute. The opposite hand may be applied externally for counterpressure. The compressions should be as complete as possible without undue traumatism, and the pressure suddenly released.

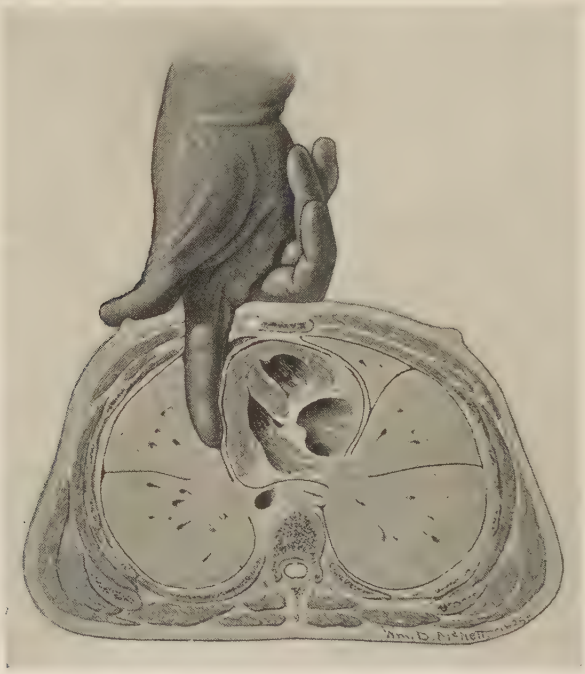


Fig. 730.—Cardiac massage, Babcock's method, by a finger introduced through a stab wound in the fourth left intercostal space. By flexing the finger the heart is compressed against the overlying thoracic wall.

2. *Transdiaphragmatic massage*, in which the hand is carried from the abdomen through an incision in the diaphragm, is unnecessary and should not be employed.

3. *Babcock's Digital Transthoracic Massage.*—A stab wound is made in the fourth left intercostal space, 3 cm. from the sternum, the index-finger introduced as the knife is withdrawn, curled around the left edge of the heart, and the heart rhythmically compressed against the overlying chest wall.

4. *Transthoracic Massage.*—The conventional method, with a trap-door osteoplastic incision to admit the hand into the thoracic cavity and to grasp the heart, is an operation not well adopted for the seven minutes permitted by the emergency. While massage of the heart is more surely and completely produced by transthoracic methods, most recoveries have followed the subdiaphragmatic method.

Cardiorrhaphy.—During the introduction of sutures the heart may be supported on the hand, or given a measure of fixation by guide sutures. It is difficult, with marked tachycardia, to time

the introduction of a needle with either systole or diastole. Sutures should avoid the coronary artery and should be carried down to the endocardium but not through it. Hemorrhage may be lessened during the introduction by pressure over the wound, or by lifting the heart through the opening in the chest wall. Torsion or excessive traction on the pedicle of the heart is dangerous, as is rough manipulation. For wounds on the posterior surface, the heart should not be rotated but the apex brought forward. The entrance of air into the right ventricle and lung, with pulmonary air-embolism, is much less dangerous than air in the left ventricle and coronary arteries with air-embolism of the heart and brain. If air has entered the heart, the left ventricle should be carefully aspirated before closing, and air-bubbles noted in the coronary vessels should instantly be removed by aspiration, using a small hypodermic needle and syringe, to prevent fibrillation. Incised wounds up to 2 mm. in length through the left ventricular wall close almost immediately, although similar wounds through the right ventricle or auricles permit a fatal hemorrhage. From the left ventricle the blood is ejected in strong systolic spurts, while the flow from the right ventricle and the auricles is almost continuous.

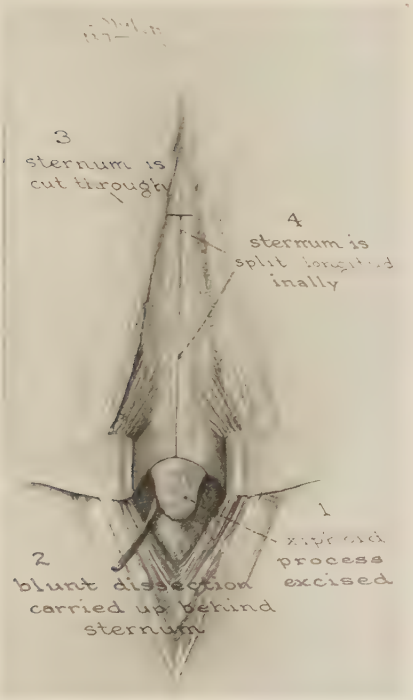


Fig. 731.—Duval Barasty incision for exposure of the pericardium and heart.

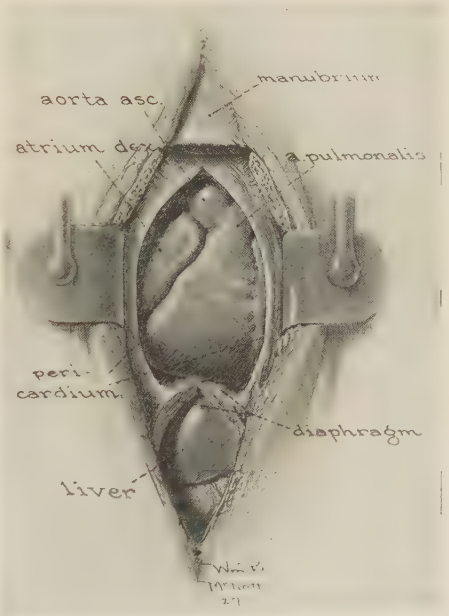


Fig. 732.—Duval Barasty incision: The halves of the sternum have been retracted and the pericardium opened, exposing the heart.

An involvement of the sino-auricular node at the ostium of the superior vena cava may be fatal.

Control of Cardiac Circulation.—Hemorrhage from the heart may be controlled by compressing the venæ cavæ at their entrance into the right auricle (Rehn, 1907). The veins may conveniently be compressed between the middle and ring fingers of the left hand, upon the palm of which the heart rests. The great pedicle of the heart may also be compressed by a rubber-covered Doyen clamp. An arrest of circulation through the heart is tolerated for from five to seven minutes, and for a somewhat shorter time in lower animals.

Operative Exposure of the Heart.—The *median thoraco-abdominal pericardiotomy* of Duval Barasty exposes all parts of the heart without the production of pneumothorax. An incision is made from the second rib to the midepigastrium, the xiphoid is excised, the sternum is split to the second

interspace and is there cut transversely. The split halves of the sternum are retracted, the pleura dissected away laterally, the pericardium opened anteriorly, and the diaphragm and anterior pericardium split for from 5 to 8 cm. toward the crus.

Spontaneous rupture of the aorta is rare and usually involves the part within the pericardium. Intense muscular exertion increases the pressure within the aorta, and overextends the longitudinal fibers, which give way if sufficiently degenerated. Chronic nephritis, cardiac hypertrophy, arteriosclerosis, and increased intra-abdominal pressure favor the rupture. Aortal rupture follows the falls of aviators, with overextension and fracture-dislocation of the spine.

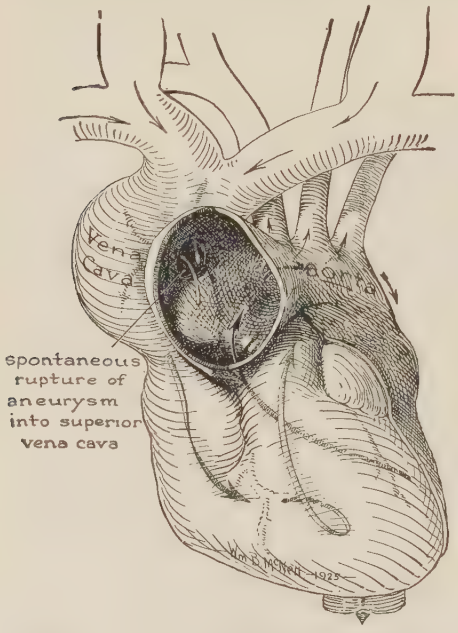


Fig. 733.—A lateral opening between the arch of the aorta and descending vena cava interrupts the venous return to the heart and is followed by enormous venous congestion of the upper part of the body and usually by death in seven to nine days. Lateral arteriovenous anastomoses are very harmful.

Wounds of the thoracic aorta, penetrating or perforating, are not always fatal. In Captain Stoke's case a bullet entered the aorta and was found in the right common iliac artery five days later, when the patient died from another cause.

Hard, rough, or sharp-edged foreign bodies, lodged in the esophagus or bronchi, frequently ulcerate into the aorta after several days or weeks, with fatal hemorrhage. The aorta may be penetrated by stab or gunshot wounds, or be weakened and give way after irradiation. Diseases—such as carcinoma of the esophagus, adjacent purulent caseous lymphatic glands, pulmonary abscesses, tuberculosis, post-typhoidal vertebral disease, or gravitation abscess—may invade the aortic walls with secondary rupture.

Treatment.—In stab and gunshot wounds, if the hemorrhage is not immediately fatal, prompt exploration and arterial suture should be attempted. For the *abdominal aorta* a transperitoneal operation is indicated. Associated injuries of the gastro-intestinal canal should not be overlooked. The *ascending thoracic aorta* is best reached by an intercostal incision in the fifth right intercostal space, outside the pleura; the *descending aorta*, through the seventh or eighth left intercostal space close to the spine.

Arterial Suture.—Suture of the aorta is feasible, but not ligation of the thoracic aorta. Recovery has followed ligation of the abdominal aorta in one instance. Complete obstruction of subclavian, axillary, and common iliac arteries may cause gangrene but seldom immediate death. The superior and inferior venæ cavæ may be ligated peripheral to the azygos or the renal veins. Ligation of the portal vein is always fatal. The pulmonary artery can be

occluded for only fifty-five seconds. Simultaneous elimination of the pulmonary veins causes death in a few moments. Occlusion of the ascending aorta for more than seven minutes is fatal. The descending aorta may be occluded for a much longer time. The farther away from the heart the ligation is made, the better it is tolerated. Lateral occluding forceps are used to enable the introduction of sutures without interrupting the circulation. Experimentally, an injured aorta has been treated by resection and suture over a glass tube, the tube being removed before the final sutures were tied. Even the operative exclusion of the arch of the aorta has been considered (Jeger).

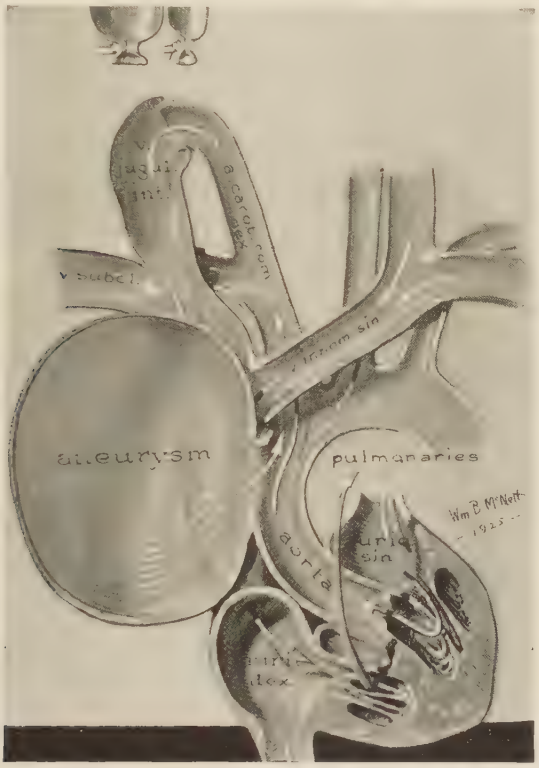


Fig. 734.—An end-to-end anastomosis between a large artery and vein, directed toward the heart, accelerates the venous return and by the increased velocity may reduce the wall pressure in the vein. The diagram illustrates the rapid leak from an aneurysm of the aorta back to the right heart by the anastomotic operation of Babcock. After such an operation a patient has lived with improved health for over three years.

In animals, Lebsche obtained sufficient blood from the left heart to supply the central nervous system through a lateral anastomosis between the ascending and descending aorta or between the left ventricle and descending aorta. It is questionable if these experiments can be applied in human practice. Transient interruption of blood-supply to the left heart, as by compression of the right *atria venosum*, is tolerated for but a few moments without degeneration of the heart and brain. In a few cases aortal injuries have been successfully repaired. The few patients who endure the first profuse hemorrhage usually

succumb to the second hemorrhage, so the surgeon should permit no delay. The opening may be found occluded by the projectile, tissue, or bone. Brentano's patient survived seventy days after double perforation of the abdominal aorta by a full mantled bullet, but died of sepsis. Traumatic aneurysms often form from the injury, and death follows rupture (as into the esophagus), thrombosis, embolism, or infection. Eshanelidze successfully sutured, by splitting the pericardium, an 8 mm. stab wound of the ascending aorta, which was found covered by a thrombus. Operations for trans- and extra-pleural excision and resections for aneurysms of the thoracic aorta have invariably failed.

CHAPTER XLVII

THE ABDOMINAL WALL

Abdominal Wall.—Applied Anatomy: The *line of cleavage* of the skin is nearly transverse. Thus vertical scars tend to stretch, while transverse scars become less conspicuous with time.

The *principal muscles* to be considered in abdominal surgery are the recti and pyriformis (anterior group), the internal and external oblique and transversalis (lateral group), the psoas, quadratus lumborum, latissimus dorsi, lumbar fascia (posterior group). The sheath of the rectus, a strong aponeurotic layer, surrounds the upper three-fourths of the rectus, but is absent posterior to the rectus in its lower fourth, or below the semilunar fold of Douglas.

The *blood-supply* comes chiefly from the inferior and superior epigastric vessels.

The *nerves* are so distributed that the skin and external surface of the peritoneum are the most sensitive layers of the abdominal wall and require special infiltration for local anesthesia. The innervation of the abdomen is chiefly through the lower six intercostal nerves. The seventh to the eleventh thoracic nerves pass through the base of the diaphragm, run forward and penetrate the transversalis, continue between the internal and external oblique to the posterior sheath of the rectus, and pierce the rectus and its anterior sheath, to supply the skin from the xiphoid to a point below the navel. The twelfth dorsal passes under the last rib, under the psoas between the lumbocostal arch and quadratus lumborum, penetrates the transversalis, runs between the transversalis and the oblique, sends branches through the rectus, and supplies the lower abdominal wall and the adjacent skin of the buttocks and hips below a line half-way between the navel and pelvis.

The *iliohypogastric* passes through the psoas to the surface of the quadratus behind the kidney, and runs laterally between the internal oblique and the transversalis to $2\frac{1}{2}$ cm. internal to the anterior superior spine, where it penetrates the internal oblique and runs between the external and internal oblique and, by piercing the external oblique 3 cm. above the subcutaneous inguinal ring, becomes subcutaneous.

The *ilio-inguinal* runs parallel to and below the iliohypogastric, passing through the subcutaneous inguinal ring.

The *genitofemoral* runs on the psoas, lateral to the iliac vessels, and behind the ureter to the inguinal ligament. One branch then passes through the inguinal canal to the scrotum and adjacent thigh, and the second goes to the skin of the femoral triangle.

The *spinal nerves* supplying the abdominal wall communicate by gray rami (visceral) and white rami (vasomotor) with the sympathetic system (splanchnics).

Very sensitive branches of *parietal* nerves innervate the outer layer of the parietal peritoneum and, when irritated, cause reflex spasm of the overlying muscles.

Pain or tactile sensation is not appreciated in organs having only sympathetic innervation. Thus, the visceral peritoneum, visceral mucosa, liver, gall-bladder, spleen, kidneys, pancreas, and omentum are insensitive, while the neck of the gall-bladder, the ducts, and the ureters are sensitive. The mesentery has non-localizing sensation, leading to deep epigastric distress, tormina, and nausea. Gastro-intestinal colic may result from traction or pressure on the mesentery or parietal peritoneum.

Peristalsis is inhibited by vasomotor nerves. The vagus, which has no sensory fibers, is the motor nerve of the stomach and upper intestine. The intrinsic ganglia of Auerbach and Meissner initiate peristaltic movements in the intestine.

Visceral reflex arc carries impulses from the irritated abdominal organ through the splanchnics, gray rami, lower intercostal, or lumbar nerves to the overlying parietal muscles which reflexly contract causing *involuntary rigidity* of the abdominal wall. The reflex usually originates in irritated parietal rather than visceral peritoneum, and the area of muscular spasm, either local or diffuse, lies directly over the area of local or diffuse irritation within the abdomen.

Incisions and Nerves.—Transverse incisions give the finest linear scars. Incisions across the nerves cause muscular paralysis, weakness of the abdominal wall, diastasis, and cutaneous paresthesia. Separation, rather than division of fibers of the abdominal muscles and aponeuroses (*gridiron incisions*), and wound closure with overlapping of aponeurosis (imbrication) give the strongest scar. Failure to close the aponeurotic layers favors the development of incisural hernia.

Abdominal Points.—Certain abdominal landmarks or "points" are useful for purposes of localization: (1) McBurney's point is about 5 cm. from the right anterior superior iliac spine on a line running thence to the navel. It lies over the base of the appendix. (2) *Morris' points* lie about 4 cm. lateral to the navel, on lines running from the navel to the anterior superior iliac spines. If tenderness on pressure is found at both points it suggests ovarian disease; if at the right point only, appendiceal disease. (3) *Robson's point* is at the junction of the middle and lower thirds of a line from the right nipple to the navel, and lies over the duodenum. (4) *Desjardins' point* is 5 to 7 cm. from the navel, on a line to the right axilla, and lies over the head of the pancreas.

Diagnosis of Abdominal Disease.—Inspection: 1. *Color:* Lemon color is seen in anemia, cachexia, or cancer; yellow in jaundice; brown in Addison's disease, and gray in argyria.

2. *Surface:* The surface is smooth, shiny, tense, and pale from abdominal distention and edema. It is dry, wrinkled, and scaly from emaciation and malnutrition. Lineæ albicantes indicate stretching of the skin as from a previous pregnancy. The skin becomes coarse ("pig-skin," "orange-rind") from lymphedema, cancer, or inflammation.

3. *Contour:* Fulness in the flanks suggests intraperitoneal effusion. Enlarge-

ment of one flank, a renal growth or perinephric abscess. Anterior enlargement with the contour changing on respiration suggests fluid or gaseous distention, or obesity. An abnormal contour maintained but moving with respiration, suggests an enlargement or growth of the liver, stomach, spleen, kidney, or intestine. A contour maintained and not moving with respiration, suggests a distended bladder, uterus, ovarian tumor, retroperitoneal or other fixed tumor, or a tumor or inflammatory mass of the abdominal wall.

4. *Enlarged veins* may result from caput medusæ, portal obstruction from cirrhosis or cancer of the liver, underlying sarcoma, and thrombosis of abdominal veins.

5. Nodules of recent origin in the skin suggest metastatic tumors.

Fig. 735.—Enlargement of superficial abdominal veins from obstruction to the portal circulation (malignant disease of the liver [?]).

Fig. 736.—Echinococcus cysts forming in the anterior abdominal wall after removal of echinococcus cyst of the liver.

Palpation.—*Involuntary muscular rigidity*, shown by the absence of reflex on scratching the skin of infants, or inability to voluntarily relax the abdominal muscles in adults, indicates peritoneal irritation, as from the entrance into the peritoneal cavity of gas, blood, pus, or alimentary products. If the rigidity is diffuse or generalized, involving all of the anterior abdominal wall, it usually indicates a generalized peritonitis.

A parietal mass moves with the abdominal wall and is usually a tumor, abscess, or foreign body. A mass which is not fixed to or movable with the abdominal wall is intra- or retro-peritoneal. Emphysematous crackling is indicative of a gas-forming micro-organism or communication with a hollow viscus or the lungs. If the peritoneum is roughened by inflammation or new growths,

there may be *friction fremitus*. A heaving, exaggerated pulsation of the abdominal aorta, with diminished or absent pulsation in the iliacs suggests an aneurysm of the abdominal aorta. In a thin neurotic patient the normal pulsation of the aorta is often very evident and may annoy the patient.

Percussion.—*Obliterated liver dulness* occurs from intestinal distention or perforation with free gas in the peritoneal cavity (*pneumoperitoneum*). The *coin test* should be used. As the descending colon lies anterior to the left kidney, percussion before and after inflation of the colon with gas is useful in differentiating enlargements of the left kidney from those of the spleen, pancreas, colon, or stomach.

Auscultation.—A bruit over the femoral arteries or aorta suggests aneurysm or pressure on the vessel; absence of peristaltic sounds, a peritonitis. A succussion splash from the stomach, six or more hours after a meal, indicates abnormal gastric retention.

Roentgen Diagnosis.—By the silhouettes on the roentgenogram or fluoroscope found after a barium or bismuth meal or enema; the injection into sinuses and fistulæ of pastes or solutions of barium, bismuth, or bromid; the introduction into the bladder, ureter, and renal pelvis of a solution of bromid or thorium; and after the elimination with the bile of substances like tetraiodophenolphthalein (opaque to the rays that are administered through the mouth or veins), peristaltic and visceral movement, foreign bodies and calculi, obstructions, ulcers, perforations, and tumors are visualized. Roentgenography and roentgenoscopy have limitations and are subject to many errors. A very accurate technic and great skill in interpretation of findings are necessary. The method supplements but does not supplant other diagnostic measures. Roentgen evidence that is contrary to other clinical findings is usually wrong. In the diagnosis of intra-abdominal conditions, the method is dependable in from 5 to 95 per cent. of the examinations, depending upon the care and skill used.

Artificial pneumoperitoneum (by the injection of nitrogen or oxygen gas into the peritoneal cavity) is a great aid in radiographic study, although it causes unpleasant and, at times, dangerous symptoms. It should rarely be used.

Gastrodiaphany.—Transillumination of the stomach by means of an electric lamp passed through the esophagus has been supplanted by more exact methods. The patient was studied in a dark room, the red glow on the anterior abdominal wall suggesting the size of the stomach, shadows indicating thickening of the anterior wall, as from tumors.

Abdominal Exploratory Operation.—In some cases a definite preoperative diagnosis is not possible. The history and clinical findings may, however, be so indicative of a serious condition within the abdomen as to warrant an "exploratory" operation. Delay in confirming a diagnosis may harm the patient, and an operative exploration is fully justified where *to look and see* protects the life of the patient better than *to wait and see*. An exploratory operation is indicated in:

1. Abdominal injury, when there is reason to fear the rupture of a viscus or a progressive intra-abdominal hemorrhage.

2. Suspected acute intestinal obstruction, perforation, leakage, dangerous inflammation or necrosis, as from a peptic ulcer or appendix, acute pancreatitis,

internal strangulated hernia, or mesenteric thrombosis; here a few hours' delay may permit a fatal peritonitis to develop.

3. Suspected incipient intra-abdominal malignant disease; here delay may lose, for the patient, the period for successful eradication.

In any case the exploration is not justified without as careful a study of the patient as his condition warrants. Applied as a general rule, the slogan "look and see" has killed many patients who have had acute abdominal symptoms from pneumonia, influenza, typhoid, pleurisy, aortic or coronary disease, and has harmed many patients with pulmonary tuberculosis, gastric crises of tabes, and symptoms of a neurosis. The exploratory operation is not justified as replacing other diagnostic measures but, as a rule, is to be used *only* when these prove insufficient. The hasty, ill-considered, or unnecessary opening of the abdomen is to be deplored.

Abdominal Wall.—Congenital Defects: *Exomphalos (ectopia viscera, hernia into the umbilical cord)* is the most common. There is a protruding sac covered by a thin layer of the jelly of Wharton, containing viscera, usually the liver. The sac, being a part of the umbilical cord, soon becomes necrotic, and a fatal peritonitis or extrusion of abdominal contents occurs. In extreme cases the viscera protrude at birth, without covering.

Treatment.—The defect should be closed immediately by operation. If the opening is large, it may be impossible to bring the edges together without dangerous tension. In such a case, a double pedicled flap of skin may be brought down from the chest; or flaps reflected from the inner surface of the forearm, which are temporarily sutured over the opening pending a later plastic closure. With small hernias into the umbilical cord the intestine may be included in ligating the funis, causing intestinal obstruction, peritonitis, umbilical fistula, or artificial anus. Obviously a ligature should not be placed over a conical or enlarged portion of the cord, or close to the abdominal wall.

In exstrophy of the bladder there is a defect of the lower abdominal wall and the anterior wall of the bladder with separation of the pubic bones.

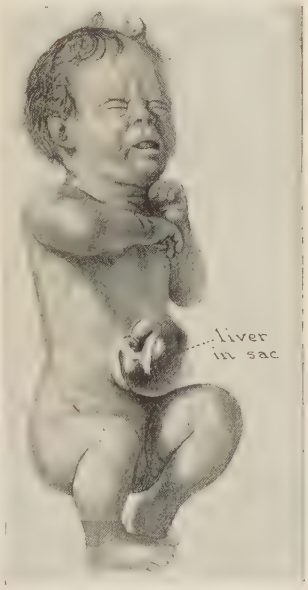


Fig. 737. Exomphalos (hernia into the umbilical cord). The liver protrudes into the sac and is covered by vitelline membrane.

Anomalies of Vitello-intestinal Duct.—This duct, connecting the intestinal canal with the yolk-sac, disappears about the eighth week. Its persistence (complete or partial) may cause a fistula, diverticulum, or cyst, appearing after the stump of the umbilical cord drops. The partially obliterated duct may form a blind pouch projecting from the intestine (Meckel's diverticulum) or, if shut off from the ileum and navel, a cyst.

Urachus.—This connects the urinary bladder with the allantois, and by the fifth month is converted into the vesico-umbilical ligament. If unobliterated, a sinus, cyst, or fistula remains. Patency has been attributed to increased

tension at the urinary outlet, as from phimosis. The fistula or sinus may be present at birth, or develop after months or years, and at first discharge pus and later urine.

Treatment should aim: (1) To relieve any obstruction to the free passage of urine; (2) to cure the cystitis, and (3) to obliterate the fistula by cauterization and pressure, or by excision.

Hemorrhage from the navel follows improper ligation, weakness of the tissues, avulsion, premature separation of the cord, or hemophilia.

Treatment consists of: (1) Religation of the cord; (2) cauterization or the application of styptics; (3) pressure compresses; or (4) if other measures fail to arrest the bleeding, acupressure is used. The umbilicus is superficially transfixed by two fine needles introduced at right angles to each other, under which a coarse silk thread or tape is wound with sufficient tension to arrest all bleeding.

Umbilical Sinus.—The umbilicus is the thinnest part of the abdominal wall, and a favorite seat for the spontaneous discharge of intra-abdominal pus, urine, bile, the contents of hydatid and other cysts, of degenerating lymph-nodes and tumors, and for the extrusion of gall-stones, round-worms, and intestinal and other foreign bodies.

Umbilical Fistula.—*Varieties:* (1) Urinary fistula from a patent urachus; (2) intestinal fistula from a patent vitello-intestinal duct, or an intestinal injury in ligating the umbilical cord; (3) acquired intestinal fistula usually results from a sloughing strangulated umbilical hernia; (4) umbilical anus is present when all the intestinal contents escape through the opening; (5) gastric umbilical fistula is rare; (6) biliary fistula, from the gall-bladder or biliary ducts, occasionally follows injury, inflammation, and ulceration chiefly from gall-stones or malignant tumors. Vitello-intestinal fistulæ may develop some time after birth by a gradual distention or rupture of the duct. A patent duct may be divided with the umbilical cord and through it the intestine may prolapse, forming a flat tumor with a relatively narrow pedicle covered by mucous membrane. If the prolapsed intestine is cut off, in mistake for a tumor, two intestinal openings remain.

Diagnosis.—Intestinal prolapse with fistula is characterized by a moist reddish tumor, covered by projecting mucous membrane, that develops as soon as the cord drops and tends to grow, with the discharge of mucus, gas, or feces. With a urachal fistula the mucous protrusion is much less. The discharge consists of mucus, pus, and urine, and a cord may be felt running in the deeper layers of the abdominal wall to the bladder. In gastric fistulæ the secretion is acid, and it erodes the adjacent tissues.

A diverticulum is to be differentiated from papilloma or granuloma by the covering of mucous membrane. If cut off, the peritoneal cavity may be opened.

Treatment.—If small, the mucous lining of an umbilical fistula should be destroyed by chemical or thermal cautery, and an occlusive pad applied. The mucous membrane must be completely destroyed to prevent recurrence. If this fails, or the fistula is large, it should be excised with the umbilical ring; the opening into the intestine, bladder, or stomach closed, and the abdominal wall united in layers. Protruding portions of small intestine with intestinal fistula should be treated by replacement, pressure, or plastic operation.

Inflammation of Umbilicus.—1. In the *newborn* serious infections and inflammations originate in the umbilical stump, including erysipelas, suppuration, phlegmon, tetanus, gangrene, arteritis, and phlebitis. The inflammation may spread to the peritoneum and along the umbilical vessels to the liver, with acute hepatitis and jaundice. *Treatment* includes prophylactic aseptic care and protection of the umbilical stump, and the following of the principles to be used in the treatment of the special forms of infection.

2. In *children* and *adults* (from uncleanliness) dirt and sebaceous material may collect in the navel, cause erythema, ulceration, umbilical granuloma, or gangrenous inflammation. The inspissated mass may even form a concretion (*umbilical stone, cholesteatoma*). Chronic inflammation of the umbilicus with granulations and foul discharge may indicate the presence of dirt and foreign substances, or eczema, syphilis, tuberculosis. A gumma may develop in the umbilicus. *Treatment* consists of removal of foreign bodies, frequent cleansing with boric-alcohol or aluminum-acetate solution, and the use of dusting-powders such as boric acid or thymol iodid. Dilatation or division of the umbilical ring may be required. Cleansing with boric lotion or 2 per cent. aluminum acetate solution is usually effective in cases of eczema. Granulations should be cauterized. Appropriate treatment should be given tuberculous and syphilitic lesions.

Granuloma (*umbilical fungus*) may develop from irritation and infection of the umbilical stump, as a soft red granulating tumor. It is to be differentiated from mucous prolapse with fistula.

Treatment consists of cleanliness, dusting-powders, cauterization, curettage or, if persistent, excision.

Tumors of the Umbilicus.—Angiomata, warts, papillomata, sebaceous and dermoid cysts, and connective-tissue tumors involve the umbilicus and are sometimes congenital. Papillary fibroma occurs in later life, and may show malignancy.

Treatment.—The first three types should be cauterized, the others enucleated.

Malignant Tumors.—Fibrosarcomata are firm, sessile and covered by normal skin showing dilated veins. They occur chiefly in women and may result indirectly from the traumatism of pregnancy.

Prognosis is favorable after early excision.

Congenital telangiectatic myxosarcoma develops in the residual portion of the umbilical cord, and often may successfully be excised.

Epithelial tumors include dermoids and sebaceous cysts which may acquire considerable size. The peritoneal cavity may be accidentally opened when they are removed.

Umbilical carcinoma may be primary or, more frequently, secondary. The primary is usually an epithelioma, forming a shallow ulcer with crusts; a papillary cauliflower mass; or a scirrhous carcinoma which ulcerates in the later stage. Colloid carcinoma is rare. In obese persons the ulcerated growth may be exposed with difficulty.

Prognosis.—The prognosis of epitheliomatous and papillomatous carcinomas is good if they are removed early. It is not as favorable with the scirrhous, and is bad in tubular and colloid forms. Secondary carcinoma from primary growths

in the liver, or other internal abdominal organ, reaches the navel through the round ligament, and indicates a hopeless diffusion of the growth.

Carcinoma is usually secondary to that of the stomach, liver, or intestines. Occasionally the primary growth is in the uterus or pelvic organs.

Treatment.—Primary cancer of the umbilicus, either of the papillary or scirrhous type, should be excised or radiated. Aggressive treatment for secondary cancer is rarely advisable.

Injuries of the abdominal wall are divided into the *closed (subcutaneous)* and *open*, depending upon the absence or presence of an opening in the abdominal wall.

Closed injuries are of two types: Those in which only the muscles and vessels are affected, and those in which the viscera are injured.

Fig. 738.—Large abscess of the right anterior abdominal wall following a fall over a banister. This condition suggested a rapidly growing sarcoma, but was due to an infected (colon bacillus) hematoma. (Dr. John H. Frick.)

Closed, Without Visceral Injury.—Contusion, strain, or muscular contraction may cause: (1) Interstitial hemorrhage or ecchymosis from division of capillaries, or a hematoma if a vein or artery is injured; (2) rupture, stretching or separation of muscles or aponeuroses (*hernia* or *diastasis*), and (3) abscess from localization of infection. Predisposing causes are vascular disease, general or focal infection, muscular wasting or degeneration from senility, obesity, or disease (*typhoid*, *pneumonia*, or *smallpox*).

Subcutaneous Injury.—The muscles of the abdominal wall rupture or stretch from: (a) Voluntary contracture with great muscular effort; (b) degeneration occurring especially in the lower rectus after typhoid, pneumonia, influenza, or other infections, wasting disease and paralysis, and (c) injury as from blows, kicks, and run-over accidents. The recti are usually affected, near the semilunar line, but the lateral muscles may also give way.

Symptoms include sharp stabbing pain, local tenderness, restriction of respiratory movements, and a posture that relaxes and protects the injured area. In other cases the patient has a sense of something giving way about the abdomen, with shock, weakness, and burning sensations radiating through the body. Swelling and ecchymosis of the external layers may be absent. A secondary hematoma, abscess, hernia, or diastasis may follow the injury.

Treatment.—Rest in bed; the abdominal wall should be relaxed by pillows or other support under the thorax and knees, and supported by an abdominal bandage, belt, or adhesive strapping. The patient may gradually resume his muscular activities after three weeks, but should continue the abdominal sup-

port for three months or more. An effusion may require aspiration or incision; a secondary hernia, a reconstructive operation.

Closed, With Visceral Injury.—The viscus may be injured by force from without, as a blow or crush; or from within, as impingement on a fractured rib, pelvic bone, or against the protruding spine, or the promontory of the sacrum. The injury follows a blow, kick, or explosion, a crushing or run-over accident, a fall on the abdomen, or an internal strain, as in vomiting. Enlargement, friability, distention, or disease of an organ predisposes it to injury, as with pregnancy, ague cake, gastric or intestinal ulcer, appendicitis, or aneurysm.

Pathology.—There may be contusion, penetration, rupture, or division of the viscus, with escape into the peritoneum of blood, urine, gastric or intestinal contents, bile or gas, with resulting septic or aseptic peritonitis. The organs most subject to injury are: The liver in the upper right quadrant, the spleen in the upper left quadrant, the kidneys in the lumbar region, the intestine in the umbilical region, and the bladder in the pelvic region.

Symptoms.—(1) Shock with pallor, rapid weak pulse, sighing shallow respiration, syncope, subnormal temperature; (2) rigidity of the abdominal wall; (3) hydro- or hemo-peritoneum, with distention and shifting dependent dulness; (4) pneumoperitoneum with diffuse tympany and obliteration of the liver dulness, and (5) empty leaking bladder. Increasing leukocytosis and increasing signs of peritonitis and ileus are usual symptoms. With fracture of the ribs or pelvis, the possibility of visceral injury should be considered, and vaginal and rectal examinations employed. In other instances, the percussion and coin tests, the hydrostatic test, and Roentgen examination are valuable.

Diagnosis.—Hemoperitoneum and injury in the upper right quadrant suggest rupture of the liver and, in the upper left quadrant, injury of the spleen. Hydroperitoneum indicates pelvic injury and a leaking rupture of the bladder. This should be confirmed by cystoscope, or a hydrostatic test with catheter, funnel, and sterile salt solution. Only measured quantities of the solution should be introduced before withdrawal. Hydropneumoperitoneum suggests a rupture of the stomach or intestines. An increasing mass in the loin indicates a ruptured kidney and hemorrhage or, if sepsis is also present, ruptured kidney and urinary extravasation.

Prognosis depends on the extent of injury, the degree of hemorrhage, infection, and the time and effectiveness of the operative treatment. Rupture of the spleen usually is fatal from hemorrhage, either instantly, within a few hours, or after a number of days. At times there is little hemorrhage, the patient being able to walk half a mile before collapsing. In other cases hemorrhages with attacks of severe pain recur every two or three days with ultimate death or recovery. Hemorrhage from a ruptured liver is less than from a rupture of the spleen of equal extent. A ruptured kidney rarely communicates with the peritoneal cavity, whereas a ruptured bladder usually does. An uncomplicated rupture of the kidney is rarely fatal, and seldom requires operation. The opposite is true with rupture of the bladder. The intestine, although not ruptured, may undergo secondary contraction and stenosis, or secondary gangrene from injury to the mesentery. Rupture of the bladder, stomach, intestines, or gall-

bladder without operation is usually followed by death from peritonitis in from two to four days.

Sequelæ.—Occasionally there are late sequelæ of closed abdominal injuries. Metabolic symptoms may arise from damage to the glandular organs. Secondary abdominal abscesses, sinuses, or fistulæ, and stricture or stenosis of the damaged intestine or ureter, or obstruction from adhesions may develop.

Treatment.—(1) Immediate operation if there is evidence of rapid continued hemorrhage; (2) if active hemorrhage can be eliminated in the diagnosis, temporary delay with rest, warmth, and possibly opiates and transfusion or infusion is often desirable to obtain reaction from intense primary shock. To aid reaction and to reduce intra-abdominal leakage, a bandage for abdominal support or compression is used. Involuntary muscular rigidity, signs of progressive or recurrent hemorrhage, free fluid or gas in the peritoneum, beginning peritonitis or ileus, or grave doubt as to the extent of visceral damage, are urgent indications for immediate operation. If the patient is in shock or collapse, local anesthesia (perhaps with a little nitrous oxid-oxygen or ethylene) is preferable to general anesthesia by ether or chloroform. A prolonged operation and chilling or exposure of the patient should be avoided.

Operation.—The incision is made over the point of injury. Hemorrhage is controlled by simple ligature, mass ligature, or special occluding suture (liver, spleen), firm gauze packing, or extirpation (splenectomy, Porro). Leakage from the stomach is controlled by suture or occluding pack; from the intestine, by enterorrhaphy, resection, artificial anus, or fistula; from the bladder, by suture; from the gall-bladder, by cholecystostomy, cholecystorrhaphy, or cholecystectomy; and from the kidney or ureter, by suture, pack, drain, or nephrectomy. If septic foreign substances remain in the abdomen, as from a ruptured bowel or stomach, a suprapubic, ventral, or lumbar tube, or gauze drain should be used, according to the indications. Secondary hemorrhage should be prevented by avoiding undue vascular stimulation, maintaining intra-abdominal tension (firm bandage), applying an ice-bag locally, and giving calcium chlorid, thromboplastin, or foreign serum intravenously.

Operation for ruptured kidney is necessary only for extravasation of urine or violent hemorrhage. Even very large hematomata about the kidney are spontaneously absorbed.

Open Injuries.—These may be (1) *penetrating*, with or without injury to the viscera, or (2) *non-penetrating.*

Treatment.—Non-penetrating wounds of the abdominal wall are treated by hemostasis and asepticization, with débridement if necessary, and careful exploration by the finger and eye under an anesthetic to make sure there is no penetrating injury. Foreign bodies are removed, and the wound sutured.

Probing should not be used. In penetrating injuries it is desirable to give an anesthetic, asepticize, and explore, not probe. Small punctures entering the cavity are often more dangerous than large wounds. The abdomen should be carefully explored for escaping urine, bile, mucus, gas, fat necrosis, or visceral injury. Free gas in the peritoneal cavity usually indicates injury to the stomach or intestine. After arresting hemorrhage, all lacerations or perforations should be sutured or occluded, devitalized tissue removed, and the abdominal

wound sutured without drainage or, if there is oozing or residual non-absorbable material, a drain should be inserted.

Diagnosis.—Involuntary muscular rigidity usually indicates an intra-abdominal injury, necessitating operation. Rigidity, however, also occurs in lower thoracic injuries, and in wounds of the abdominal wall. Retroperitoneal hematoma from wounds of the back, buttocks, and lower thorax give symptoms suggesting an intra-abdominal lesion, as does an injury of the spine. In the latter case there is associated evidence of paralysis.

A rapid pulse, which does not fall but tends to become more rapid, is an indication for operation. In the early stages, a slow pulse may be associated with serious visceral injury. Vomiting may have little diagnostic significance. The facial expression in visceral injury is serious, anxious, and drawn.

Prognosis is greatly influenced by the type of injury, and in visceral wounds by delay in operating. Gunshot wounds in war give a mortality of 50 per cent. The mortality is twice as great where the intestine is resected instead of being sutured. The best results are obtained from operation in the first twelve hours. After twenty-four hours there is little chance for recovery, unless visceral openings have been spontaneously sealed. Attempts to close intestinal wounds by suture after thirty-six hours are futile. The tissues are infected and friable, and packing or enterostomy should be used.

Multivisceral wounds are more serious than *univisceral.* Penetrating wounds without visceral injury are usually followed by recovery.

Treatment.—Early operation to arrest hemorrhage, close leaking openings, and to eliminate devitalized parts. In gunshot wounds of the abdominal wall, the abdomen should freely be opened along the wound tract, the viscera examined, hemorrhage controlled, openings closed, or occluded by packing, foreign bodies removed, and the wound partially or completely closed. Gunshot injuries of the abdomen are dangerous from peritonitis, hemorrhage, shock, and tetanus. A careful exploration should be made. Stab and gunshot wounds are particularly dangerous from overlooked visceral injury and a single bullet may cause as many as 12 perforations of the intestine and stomach. Unless very accessible or producing harmful pressure, the operation should not be prolonged to search for and remove the missile. Tetanus antitoxin should be given. If facilities for immediate operation are lacking, temporary treatment consists of rest, opium, and absolute starvation.

Weakness and Relaxation of the Anterior Abdominal Wall.—Although not infrequent in men and in persons under thirty years of age, weakness of the anterior wall occurs chiefly in women of middle age or advanced years. It may be *local*, and limited to a single area of the abdominal wall; or *general*, involving the entire abdominal wall. When diffuse, the fulness and relaxation is usually more evident in the lower abdomen than in the upper.

First Degree: The relaxation is not sufficient to cause the anterior abdominal wall to prolapse over the pubis or the inguinal ligament, when the patient is in the erect posture.

Second Degree: With the patient erect, a fold of the anterior abdominal wall hangs all over the pubis and the inguinal ligament, but does not approximate the thighs.

Third Degree: With the patient erect, the relaxed abdominal wall hangs some distance down upon the thighs.

Etiology.—1. Congenital weakness.

2. Overdistention of the abdominal wall, as from pregnancy, ovarian tumors, or ascites. Obesity increases the intra-abdominal tension, weakens the supporting walls by fatty infiltration, and adds the drag of an increased subcutaneous mass.

3. General relaxation and muscular atrophy associated with wasting and debilitating disease, or from a long paramedian incision. Extensive incisions, especially where drainage has been employed or simple through-and-through sutures used, are frequently followed by a hernial defect.

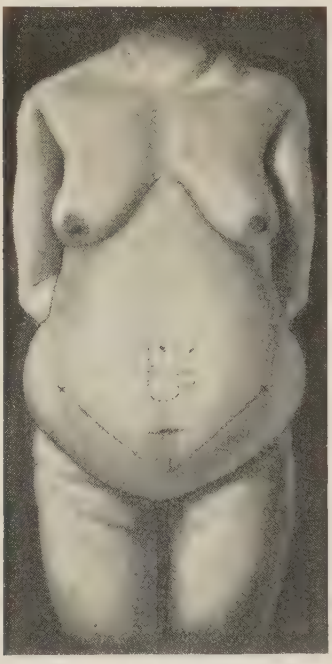


Fig. 739.—Relaxed and sagging abdominal wall, showing the displacement of the umbilicus.

Fig. 740.—Obese and relaxed anterior abdominal wall.

Symptoms.—1. A sense of weight, dragging, and discomfort felt in the abdomen and back, associated with weakness and alteration in gait and carriage due to the change in the normal center of gravity of the body.

2. Ptoses and displacement of the viscera, with the secondary symptoms due to the angulation, stasis, and obstruction that may result from visceral displacement.

3. Relaxation and distention of the stomach and intestines, due to the lack of the normal support exercised by the anterior abdominal wall, and the reduction of the normal intra-abdominal tension.

These patients therefore suffer from indigestion, headache, flatulence, con-

Fig. 741.—Lipectomy by removal of large vertical ellipse of skin and fat: The marked abdominal constriction from an extensive lipectomy is dangerous, especially in middle-aged and elderly patients.

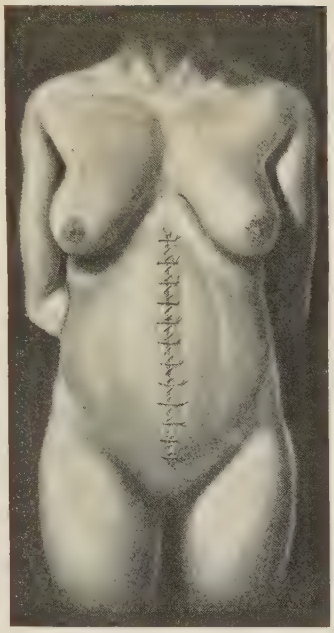


Fig. 742.—Lipectomy by excision of large vertical ellipse of skin and fat: Wound closure.

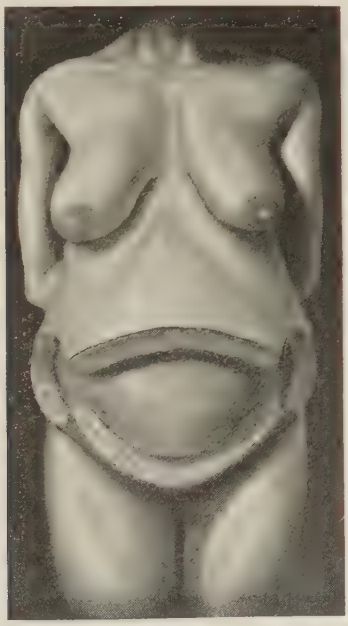


Fig. 743.—Transverse lipectomy with the removal of additional lateral ellipses of skin and fat to improve the abdominal contour.

Fig. 744.—Wound closure after modified transverse lipectomy.

stipation, and other symptoms, and often are handicapped when in the erect position.

Treatment of the weak abdominal wall may be divided into palliative and operative.

A. *Palliative treatment* includes massage and exercise to develop the weakened musculature, and the use of a supporting appliance, such as a corset, belt, or spring-truss with or without a pad or plate.

B. *Operative measures* for the correction of the incompetent anterior abdominal wall include one or more of the following:

1. The resection of an elliptic or otherwise shaped area of skin to increase the tension upon the underlying structures.

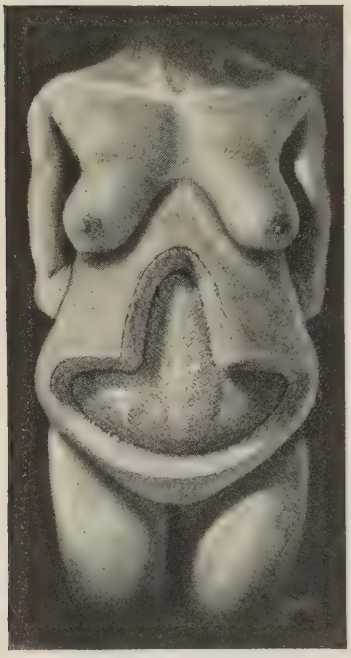


Fig. 745.—Combination of transverse and vertical lipectomy often desirable to shorten the anterior abdominal wall, as well as to reduce the redundancy over the hips.

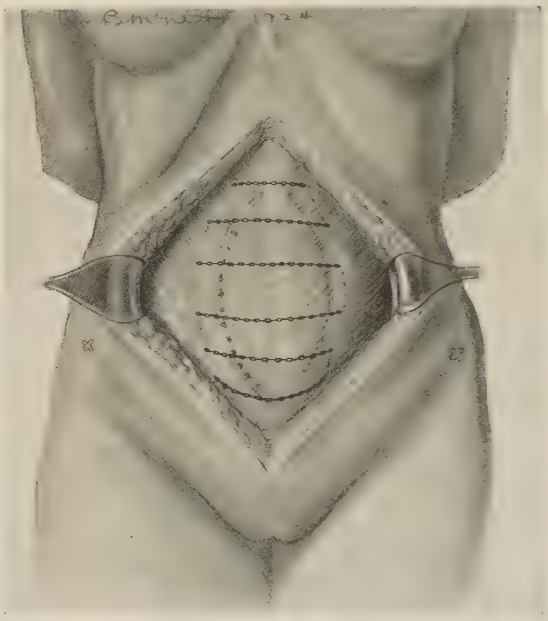


Fig. 746.—Reinforcing continuous suture of fine silver chain. While this chain, like silver filigree, will eventually break in a number of segments, it will continue to give support.

2. Lipectomy or resection of the subcutaneous fat to eliminate this source of weight and tension upon the underlying parts, and to better contour the abdomen.

3. A reconstruction of the fascial and muscular planes of the anterior abdominal wall.

4. Reinforcement of the abdominal wall by the implantation of new tissue or of foreign substances, such as silver wire, fascia lata, kangaroo tendon, etc.

In the obliteration of such defects as result from diastasis, incisural or other traumatic openings, or hernias, wide dissection is at times necessary to find and to liberate the edges of the tissue layers involved in the defect. By thoroughly freeing retracted tissues, a satisfactory closure is usually possible.

To *strengthen the deeper abdominal wall* two methods are employed:

A. Imbrication, in which one edge of the separated aponeurotic layer is lapped over the other, the imbrication being from above downward or from side to side, as seems best in the particular case. Frequently the double layer thus

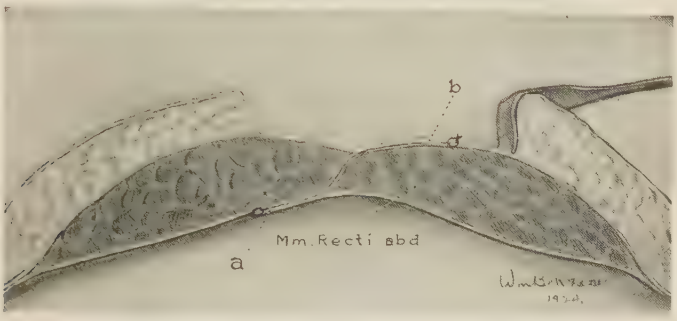


Fig. 747.—Closure of median incision of abdominal wall with imbrication of the musculo-aponeurotic layers, *a, b*. The sheaths of recti are not opened.

secured is none too thick or strong on account of the stretched and attenuated tissue.

B. Imbrication by layers, in which the abdominal wall is split into its component parts, and each layer, as is feasible, united or imbricated with its corresponding layer: Peritoneum to peritoneum, the posterior sheath to posterior

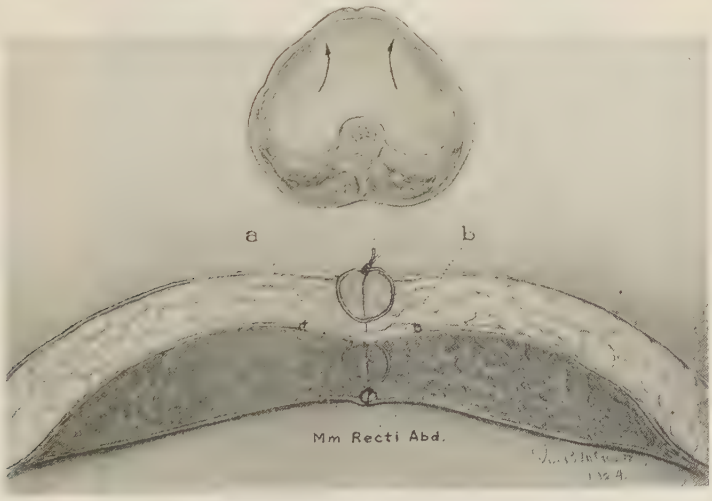


Fig. 748.—Closure of abdominal wall in layers for vertical median incision. The peritoneal edges are everted to prevent intraperitoneal adhesions. The recti are united and the anterior sheath of the rectus, *a, b*, is imbricated for stronger closure.

sheath of rectus, rectus muscle to rectus muscle, and anterior sheath of the rectus to the opposite edge of anterior sheath.

If a sufficiently strong abdominal wall is not obtained in any of these ways, additional support may be obtained by autoplastic or homoplastic transplantation of fascia, or by the use of alien substances embedded into the anterior ab-

Fig. 749.—Umbilical hernia in a woman of middle age, with obese and relaxed abdominal wall, and diastasis of recti.

Fig. 750.—Umbilical hernia: Skin incision with excision of redundant skin and fat (lipectomy). Approach to hernial sac.

dominal wall. Pedunculated flaps may be slid from one part of the abdomen to another, as in Coffey's operation; or, as a free transplant, an area of the fascia lata may be used to reinforce the anterior abdominal wall.

Use of Alien Substances.—Strips or plates of celluloid, metal, or other substances are hardly feasible. Reinforcement by a lacing with silk, celluloid linen, silkworm gut, kangaroo tendon, or similar suture material is likewise undesirable, as these substances may produce irritation or, as in the case of catgut, be absorbed. Certain metals, especially silver, are particularly well borne when introduced in the form of fine strands, and the use of a buried filigree of fine silver wire (Bartlett) or fine silver chain (Babcock) is of value. The delicate transverse loops of soft silver wire are anchored by catgut sutures. Filigree later fragments

Fig. 751.—Umbilical hernia: Hernial sac opened, exposing contained intestinal coils and omentum.

through abdominal movements, weakening the reinforced abdominal wall; and the broken sharp ends of wire may cause pain. Silver chain, by the growth of tissue through the links is more secure, and while breakage occurs, the broken strands continue to give support. Undue constriction of the abdominal cavity is dangerous.

An ellipse of redundant skin is removed. The shape of the ellipse is so altered, as to best contour the waist and upper pelvis. The skin is usually well undercut, to remove as large an amount of the subcutaneous fat as possible.

Interdigitation (Babcock).—With a large diastasis, the stretched aponeurosis between the recti may be cut into ribbons, which are interdigitated across the wound. The effect produced resembles that from interlacing the fingers of the

Fig. 752.—Umbilical hernia: Vertical division of aponeurosis. Wide diastasis of recti shown.

Fig. 753.—Umbilical hernia: Approximation of sheaths of recti with eversion of sero-aponeurotic flaps. A continuous suture of chromicized catgut is often used instead of interrupted sutures.

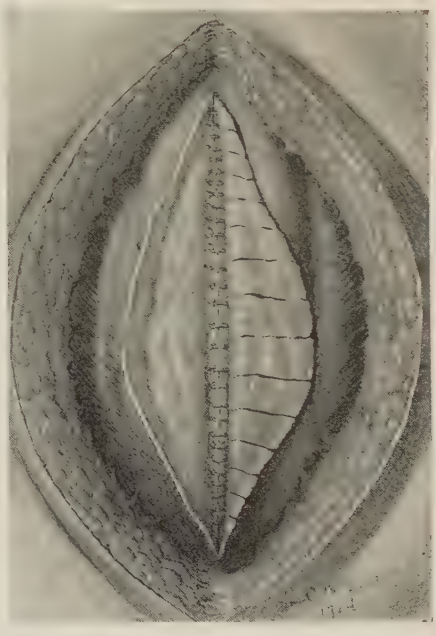


Fig. 754.—Umbilical hernia: Recti opposed. Transverse division of sero-aponeurotic flaps into broad ribbons, completed on the left side.

two hands across the abdomen. This operation is, at times, of value in *diastasis* (*divarication*) of the recti or for large median abdominal hernias.

Lipectomy (Kelly).—The removal of redundant skin and fat is often an important part of an operation for a relaxed abdominal wall. From one-half to over 20 pounds of fat and skin may be removed. Lipectomy is fairly well borne by the young, but the elderly, obese patient, particularly one with an associated myocardial degeneration, is in danger of intestinal obstruction or acute cardiac failure if the capacity of the abdomen is greatly reduced. The removal of the conventional transverse ellipse of skin and fat broadens the abdomen and produces unsightly projections at the ends of the wound. To improve the contour, smaller vertical ellipses of tissue may be removed at each end of the large ellipse. The removal of a vertical ellipse of tissue, however, usually gives a better abdominal contour than the transverse resection.

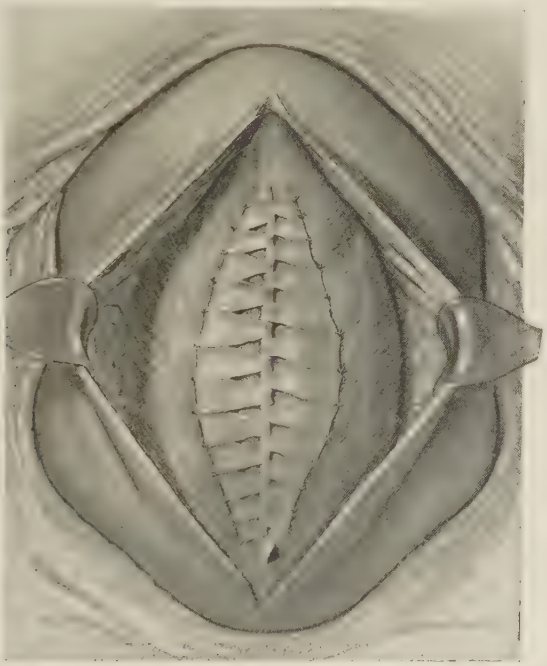


Fig. 755.—Umbilical hernia: Ribbons formed from left flap of aponeurosis and sac carried to the right, those from the right flap to the left, interdigitated, and fastened in position by interrupted sutures.

Tumors.—*Preperitoneal lipomata* are common in the midline between the ensiform and navel. They are usually small and project through the aponeurosis, suggesting a hernia with which they may be associated.

Fibroid tumors grow from the skin and subcutaneous tissues. Deep fibroma (*desmoid tumor*), growing from the rectus muscle or its sheath, develops chiefly in parous women between the ages of twenty and thirty-five, grows to great size, and not infrequently proves to be fibrosarcoma.

Treatment of benign and malignant tumors is excision.

Metastatic carcinoma occurs in the abdominal wall secondary to carcinoma

of the stomach or intestines. Examination of such a small subcutaneous mass of recent development is of diagnostic and prognostic value.

Abdominal Incisions.—**Vertical median** incision passes through the linea alba above or below the navel.

Vertical paramedian or **rectus incision** passes through a thicker, stronger area, permitting a more secure closure.

The incision may be transrectus, splitting the fibers of the rectus, usually at the junction of the middle and inner thirds; or temporarily dislocating the belly of the rectus laterad, without separating its fibers or interfering with its nerve-supply (*incisions of Lennander, Jaboulay*), or mediad *incision*

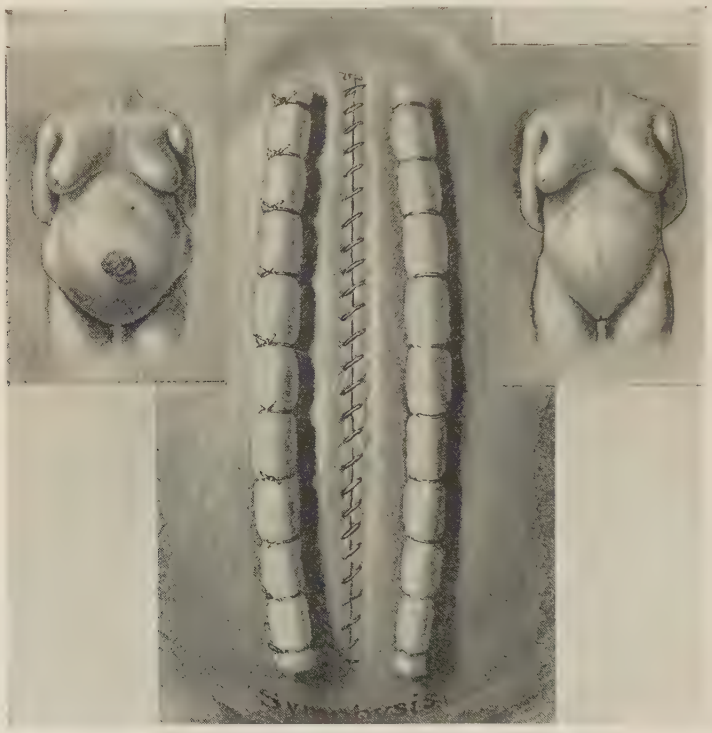


Fig. 756.—Umbilical hernia: Abdominal closure with tension after resection of anterior abdominal wall. Supporting vertical mattress-sutures of silkworm-gut tied over dental cotton rolls. Skin approximation by continuous horse-hair sutures. Inserts show condition before and after the operation.

of Battle-Jalaguier-Kammerer), which may impair the nerve-supply and injure the deep epigastric vessels.

Vertical pararectus incisions (*incisions in the semilunar line*) have the disadvantage of dividing nerves which supply the rectus muscle.

Appendiceal Incisions.—*Gridiron incision* (*McBurney's incision, McArthur's incision*), a muscle-splitting operation in which the skin is divided obliquely (better transversely), and parallel with Poupart's ligament, 4 cm. medial to the right anterior superior spine of the ilium. The length of the incision varies from 3 to 9 cm. The fibers of the internal oblique are separated obliquely, the internal oblique and transversalis are bluntly separated transversely, the transversalis fascia and peritoneum divided transversely. This incision enables a strong anatomic closure of the abdominal wall, with the least incidence of postoperative hernia.

Davis' Incision.—A 4-cm. transverse incision, level with the anterior superior spine, center-

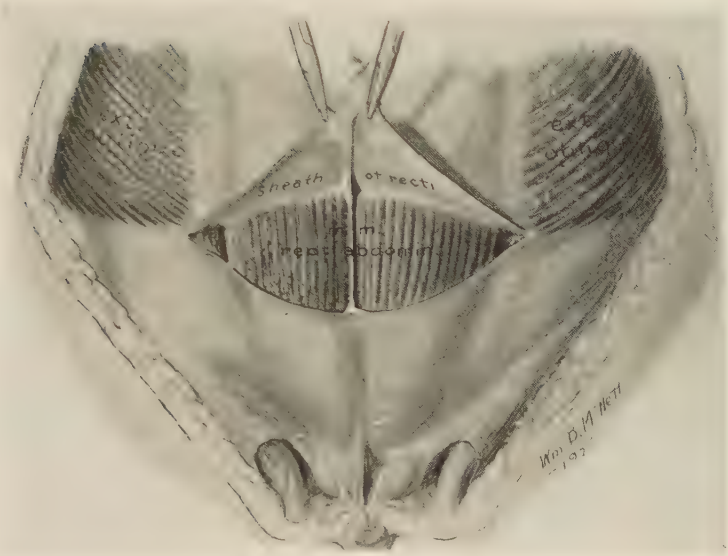


Fig. 757.—Type of abdominal incision to avoid injury to muscles or nerves. Pfannenstiel's incision, showing liberation of sheath of recti by division of fibrous partition between the muscles. The anterior sheath has two layers which may be united separately.

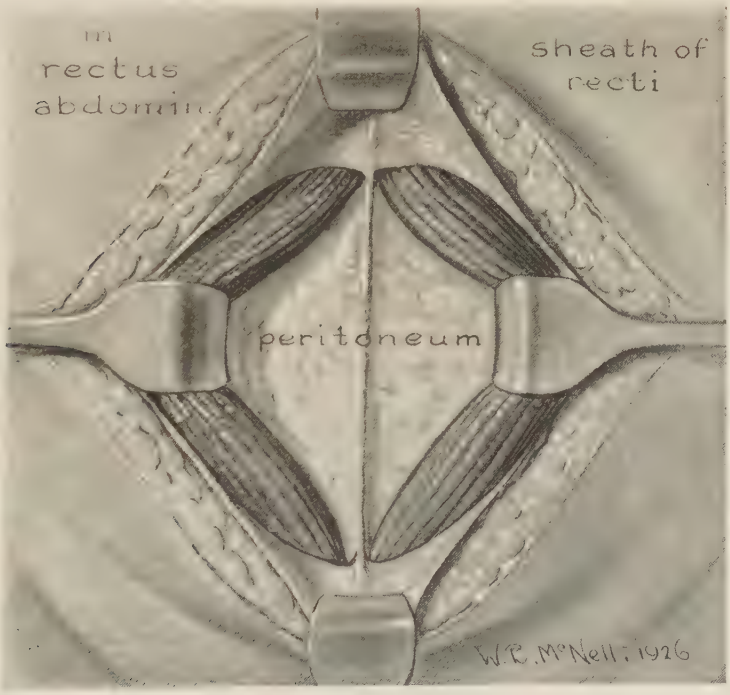


Fig. 758.—Pfannenstiel's incision, showing peritoneum exposed, to be divided vertically.

ing over the outer edge of the rectus. The anterior sheath of rectus and the peritoneum are divided transversely, the rectus retracted medially.

Gall-bladder Incisions.—*Mayo-Robson's Incision.*—Vertical, 5- to 8-cm., right transrectus incision, which is prolonged in an angular direction toward the xiphoid if more room is required.

McArthur's Incision.—Vertical upper transrectus incision, with transverse division of the posterior sheath and peritoneum.

Bevan's Incision.—Vertical incision through outer border of the upper right rectus. The incision is prolonged obliquely upward and mediad at its upper end, and downward and laterad at its lower end, with a corresponding division of the rectus.

Kocher's oblique incision is 10 cm. long, parallel with and 4 cm. below the right costal margin. It is objectionable as it divides intercostal nerves.

Perthe's Angular Incision.—Vertical right rectus incision from ensiform to umbilicus. From the lower end, a horizontal extension crosses the rectus to costal margin, dividing rectus between sutures that unite the muscle to its anterior sheath. Posterior sheath of the rectus and peritoneum are divided obliquely on a line parallel with the right costal arch.

Simple transverse incisions to outer edge of rectus (Morrison), or with division of the rectus, may be closed with less tension than the vertical incisions.

Pfannenstiel's Incision.—A curved transverse incision, the convexity downward, in the line of skin cleavage, is made just above the symphysis, passing transversely through the skin, superficial fascia, aponeurosis, and anterior sheath of the rectus; exposing the pyramidalis and recti, which are separated in the median line, the peritoneum being opened vertically.

CHAPTER XLVIII

THE PERITONEUM

PERITONITIS

Definition.—Inflammation of the peritoneum.

Varieties.—A. *As to Duration:* (1) Acute; (2) subacute; (3) chronic (tuberculous, actinomycotic).

B. *As to Situation:* (1) Local or circumscribed (peritoneal abscess); (2) diffuse or spreading; (3) general; (4) pelvic.

C. *As to Cause:* (1) Pyogenic (B. coli, streptococcic, staphylococcic, gonorrheal, pneumococcal); (2) perforative; (3) appendicular; (4) puerperal; (5) malignant; (6) terminal; (7) hematogenic (primary idiopathic); (8) tuberculous, actinomycotic; (9) radiogenic, etc.

D. (1) *Primary:* A primary peritonitis by infection through the bloodstream is rare, and usually is pneumococcal. (2) *Secondary* (*common form*): (a) Spread of adjacent infection by perforation, rupture, leakage of bacteria or irritating substances; or (b) as secondary to a general infection through the bloodstream, as in pyemia, septicemia, pneumonia, etc.

Etiology.—A. *Bacteria* and their toxins, the effect being modified by *bacterial conditions:* (1) Variety of organism; (2) virulence or attenuation of the particular strain; (3) symbiosis; (4) number or dose of bacteria; (5) blood-clot or other substance in the peritoneal cavity serving as a nidus for bacterial growth.

B. *Chemical Irritants.*—Gastric juice, bile, intestinal contents, urine, blood, fluid from hydatid cysts, Dakin's fluid and other antiseptic solutions, and even air, water, blood-clot, physiologic saline, mineral oil, and sterile potato are locally irritating, or reduce the resistance of the peritoneum to bacterial infection.

C. *Mechanical Irritation.*—Drying, sponging, and handling produce an aseptic peritonitis, and reduce the resistance of the peritoneum to infection.

D. *Other Physical Irritants.*—Roentgen rays, radium, actinic light, heat, and electricity may irritate the peritoneum.

Resistance of the patient to peritonitis is reduced in infancy, and in old age, by alcohol or drug addiction, obesity, toxicity, diabetes, nephritis, and asthenia and, after infection has started, by movement and exercise. Liquids, solid food, laxatives, and other agents that increase peristalsis favor the spread of infection, and interfere with localization. Opiates, while useful by reducing peristalsis, are probably harmful by lowering the general resistance, blocking elimination, and impairing the detoxicating action of the liver. Ether and chloroform anesthesia, cyanosis, intraperitoneal manipulation, exposure of the peritoneum to the air, irrigation, sponging, antiseptization, and prolonged operation also reduce the resistance.

Pyogenic Bacteria in the Peritoneum.—*Colon bacillus* produces abundant, dirty yellow pus with foul odor, without localizing adhesions. It is virulent in pure culture but, when associated with the adhesion-exciting staphylococcus (as is usual), it often causes a localized peritonitis of moderate gravity.

Streptococcus.—1. Hemolytic streptococcus varies greatly in virulence. In the intense acute epidemic infection, as seen in the war time influenza, it causes large serous effusions in pleural, peritoneal, and other serous cavities, usually with intense toxemia, prostration, and death, often within twenty-four to forty-eight hours. If the patient lives sufficiently long, a creamy pus is formed. Less intense streptococcic infections of the peritoneum often occur.

2. Non-hemolytic streptococcus produces effects which vary between an intense peritonitis with great vascular injection, exfoliation of endothelium, little pus, a rapidly fatal toxemia, and a mild reaction insufficient to interfere with wound healing. The puerperal type is very fatal and is made worse by operative manipulation, while streptococci from the opened stomach, gall-bladder, or appendix often are only moderately virulent, and are promptly destroyed and removed from the peritoneal cavity.

Staphylococcus albus has little virulence, producing either no reaction or a milky pus and much plastic exudate. In association with the colon bacillus it is protective by stimulating the production of localizing adhesions.

Staphylococcus aureus is more virulent than the albus.

Pneumococcus causes the formation of a thick, yellow, odorless creamy pus with pus-clots (*purulent fibrin*) and much plastic exudate. Pneumococcal peritonitis occurs in a mild and spontaneously subsiding form, with localized abscess; or as a general and very fatal form, especially when the pneumococcus enters the peritoneum by way of the vagina in young girls.

Gonococcus usually enters the peritoneum from leaking pus-tubes, the small amount of pus forming milky white lines where the intestinal coils are in contact, with little injection, desquamation, or adhesion. It is rarely virulent in the general peritoneum, and the peritonitis usually subsides spontaneously and is not intensified, but rather benefited by operation, exposure, and laxatives. After operation the gonococcus does not cause stitch-abscess, and a gonorrheal peritonitis does not require drainage.

Enteric Group.—Bacillus typhosus, pyocyaneus, the anaërobic group, and other pyogenic bacteria occasionally cause severe peritonitis.

Secondary peritonitis is common, and may originate from trauma or inflammation with perforation, rupture, leakage, or spreading infection from:

1. *Appendix* (perforation, gangrene).
2. *Fallopian tubes* (gonorrheal, puerperal, ectopic, or tuberculous salpingitis).
3. *Gall-bladder* and *ducts* (cholecystitis, traumatic rupture, perforation, escape of stone or bile).
4. *Stomach* and *duodenum* (peptic ulcer, carcinoma, phlegmonous gastritis, perforation from inflammation, foreign body, or caustic).
5. *Intestines* (perforation from typhoid, dysenteric, tuberculous ulcer, diverticulitis, cancer, or foreign body).
6. *Pancreas* (trauma, hemorrhagic or necrotic inflammation).
7. *Liver* (abscess or hydatid cyst).

Fig. 759.—Type of acute, diffuse peritonitis from gangrenous appendicitis of twelve hours' duration. Intestinal coils and parietal peritoneum injected with excess of slightly turbid serum. Bacteria, chiefly intracellular, present in region of appendix, but not in more distant portion of peritoneal cavity. Simple ligation and removal of appendix through a small incision without drainage, sponging, or intra-abdominal manipulation is indicated. The omentum has been removed for greater clearness in the illustration.

8. *Adjacent abscess* rupturing into the peritoneum (ovarian, perinephric, subphrenic, lymphatic, psoas, acetabular, of the abdominal wall, and the like).

9. *Foreign Bodies:* (a) Swallowed (human ostrich, insane, and children); (b) gall-stones; (c) parasites (ascaris lumbricoides, hydatids); (d) operative (instruments, needles, sponges, or pads). A sea-sponge tends to encapsulate; gauze, to perforate adjacent hollow viscera; metal articles, if small, may be encapsulated, if large or pointed usually enter adjacent viscera; (e) traumatic perforation (penetrating wounds, stab and gunshot injuries, perforation by

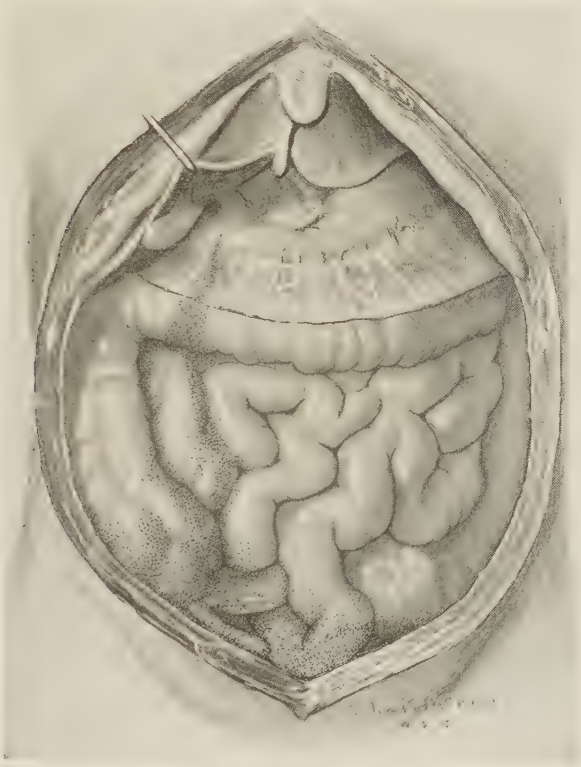


Fig. 760.—Secondary peritonitis from the acute perforation of duodenal ulcer illustrating the dissemination and collection of the chyle about the appendix. The intense pain and local tenderness referred to the lower right quadrant may lead the surgeon to remove a highly injected appendix and overlook the perforated ulcer. Mucilaginous rather than serous fluid in the peritoneum should instantly suggest a perforated ulcer.

stomach-tube or gastric bougie, by rectal tube, probe or sigmoidoscope, perforation by urethral catheter or other vesical instrument, or by uterine sound or curet).

Pathology.—In general, an insult to the peritoneum is followed by an arrest of peristalsis and, if the parietal peritoneum is involved, a rigid contraction of the overlying abdominal wall. Thus, the great factors in the treatment of any acute inflammation are at once invoked—rest, support, and protection. If the duodenum is divided or perforated, spasmodic contraction of the pylorus occurs, suf-

ficient to prevent leakage from the stomach for a period up to two hours. If, during this time, the patient unwisely takes liquids or solids, these are promptly ejected by vomiting. If the irritation is in the lower ileum or cecum, the pylorus spasmodically closes through the ileopyloric reflex, and substances introduced into the stomach are expelled by vomiting. Likewise, enemas are either retained, or are expelled with little gas or fecal matter. In a typical case, the first reaction, the intestinal spasm, gives the initial symptom of diffuse abdominal colic, which is soon followed by nausea and efforts to empty the stomach, and by localization of pain over the point of greatest irritation. With peristalsis

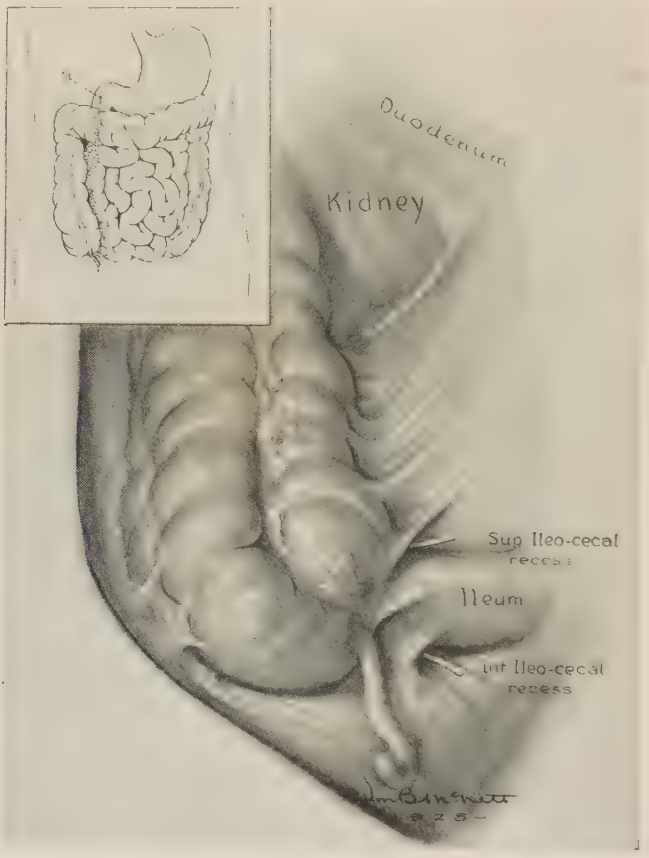


Fig. 761.—Fossæ about the kidney and ileocecal angle which may catch fluid escaping from a perforated duodenal ulcer: *a*, Fluid leaking from perforated duodenal ulcer.

arrested and the stomach emptied, the peritoneum throws out plastic exudate to wall off the area of irritation, together with serum and cells to neutralize and overcome the infection. If not interfered with, these natural processes usually are efficient. The peritoneum becomes red and injected or lusterless, and exudes serum and the elements of plastic exudate. Useless and dead cells are removed by phagocytic free endothelial cells, which are active in the normal peritoneum and in the recovering stage of peritonitis. Bacteria are destroyed and removed by phagocytic large mononuclear leukocytes and the polymorphonuclear

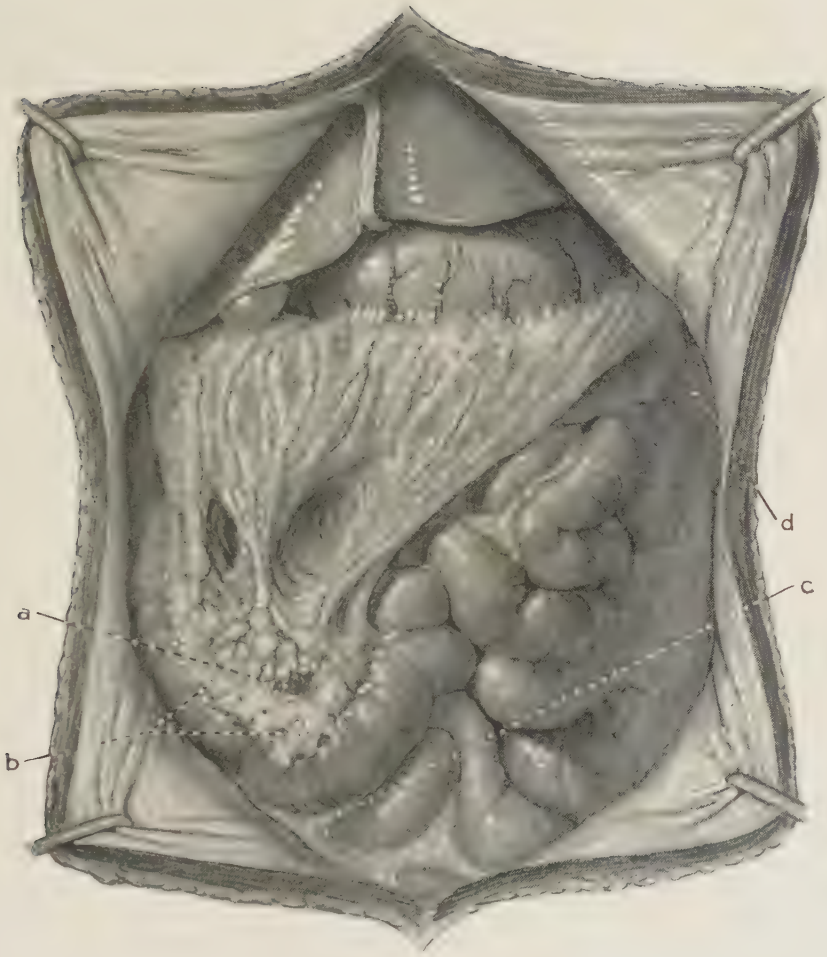


Fig. 762.—Type of gangrenous appendicitis partially localized with purulent peritonitis. (*a*) Omentum adherent over appendix. (*b*) Adjacent greenish-yellow protective plastic exudate that should never be removed by the surgeon. (*c*) Protective or truly "laudable" pus in the pelvis; not to be diluted or removed. (*d*) Highly germicidal turbid serum in the left flank, protective, and not to be disturbed. Complete localization usually occurs in this type if the patient is not given liquid food or other peristaltic stimulant.

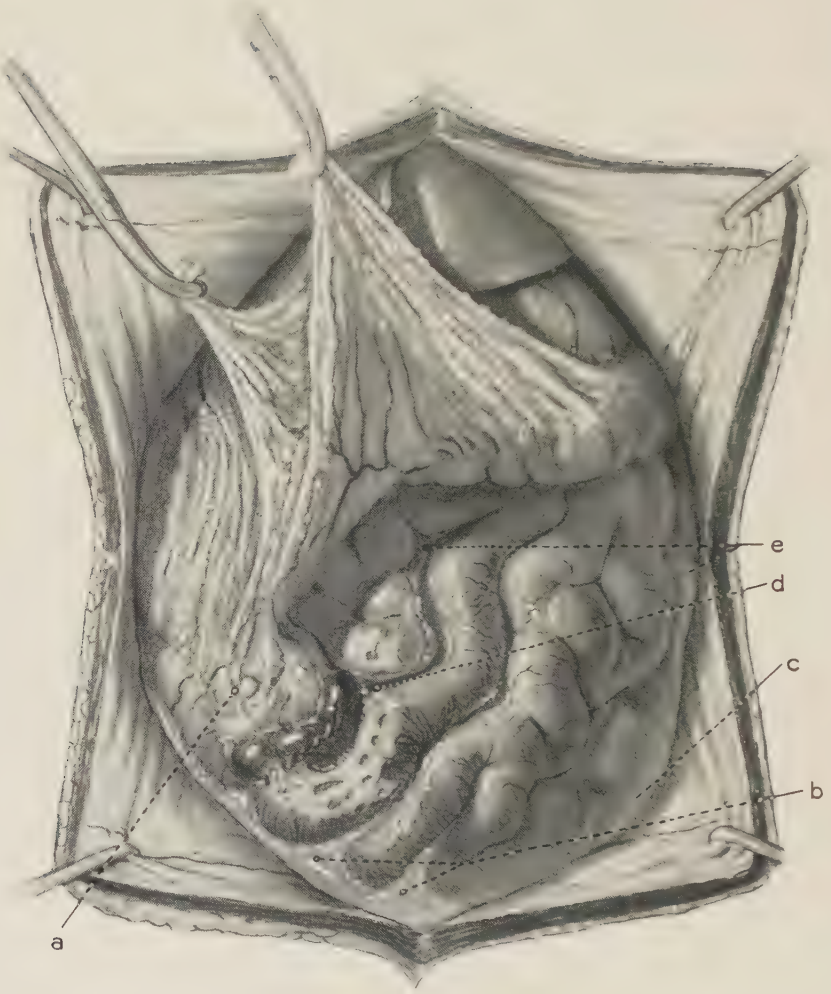


Fig. 764.—Type of gangrenous appendicitis partially localized with purulent peritonitis continued. The omentum has been partially detached and raised. (a) Gangrenous appendix. (b) Omentum adherent to cecum. (c) Protective pus in pelvis. (d) Thinner pus with few bacteria. (e) Turbid, sterile serum. A small local incision with simple ligation and removal of the appendix and the least possible separation of adhesions, or removal or disturbance of peritoneal exudate is indicated. A rubber tube may be left in the incision as a vent to the right pelvis and a cigarette-drain to the bed of the appendix. Mortality 7 per cent.

leukocytes. The phagocytosis of bacteria is reduced by extreme virulence and great numbers of bacteria (Muir, Beatie, Dudgeon and Ross, Carslow).

Peritoneal serum, plastic exudate, and fresh pus are bactericidal, bacteriolytic, and antitoxic and, distant from points of leakage or bacterial multiplication, it is often sterile and should not be removed. Old, dead, badly contaminated pus requires evacuation.

Absorption from the Peritoneal Cavity.—The peritoneum has a surface area somewhat greater than that of the surface of the body, and an absorptive capacity for water greater than that of the stomach or intestines. An animal may absorb its weight of salt solution from the peritoneal cavity in twenty-four or forty-eight hours, yet the absorption of the septic products of peritonitis is, in the normal course of events, amazingly slow. Note that an infection which, if in the pharynx, the lungs, the pleura, the biliary radicles, the kidneys, or the veins, causes a violent chill, high fever, and a drenching sweat, produces no chill and only a moderate temperature reaction if in the peritoneum. In a degree it suggests the comparison between a brain abscess and septic sinus thrombosis. The peritoneum in acute peritonitis changes from an absorptive to an exudative membrane, exudation occurring into the cavity and the peritoneal space. For the patient's protection, it is most important that it remain exudative, and such manipulations as irrigation, sponging, exposure to the air, removal of exudate, or separation of adhesions which cause absorption should carefully be avoided.

Under favorable conditions the plastic exudate, aided by the mobility and tendency of the omentum and other structures to contract adhesions, will wall off a leaky or septic area in one-half hour or longer. Later the early plastic adhesions become firm and organized. A perforating peptic ulcer may thus be sealed and converted into a subacute or chronic perforation, while gunshot wounds of the intestine treated by rest and starvation may close without operation, as shown in the Boer War.

Symptoms.—A. **Early:** (1) *Abdominal pain* which is sharp, cutting, and increased by movement and pressure. It is widespread or referred to the navel, and may be so intense as to cause shock as in perforated gastric ulcer, or so slight as to be unrecognized in a ruptured typhoid ulcer or in tuberculous peritonitis. (2) *Abdominal tenderness* with sensitiveness of the skin; and, as a reflex through the splanchnics and lower intercostal nerves:—(3) *Muscular tension* or rigidity of the overlying abdominal wall. (4) *Nausea and vomiting* of gastric contents and bile, often precipitated by taking food or medicine by mouth. (5) *Decubitus* is dorsal with knees drawn up, head and shoulders elevated, abdomen protected, the patient avoiding movement. (6) *Respiration* is shallow, quiet, and costal, not abdominal. (7) *Pulse* is strong and full, 80 to 90. (8) *Temperature* is subnormal, normal, or slightly elevated. (9) *Sharp pain in bladder* occurs at onset of certain cases of typhoid perforation and appendicitis or is, at times, referred to the *scapula* in perforation of the gall-bladder or a gastric ulcer.

B. **Latent Period.**—Four to twenty-four hours after the onset, the vomiting, pain, tenderness, temperature, and nausea subside, especially with onset of intraperitoneal gangrene. The pulse-rate is increased, and the muscular rigidity may temporarily disappear or become localized over the area of greatest inflammation.

C. **Period of Active Inflammation and Toxemia.**—(1) *Facies* anxious, pinched, and pallid; eyes bright and sunken, with circumoral pallor, and a slight dusky flush on cheeks. (2) *Abdomen distended*, tympanitic, immobile during respiration, quiet (no peristaltic sounds), shifting dependent dulness, or there may be free gas in the peritoneum with obliteration of liver dulness (from perforation of stomach or intestines or action of the colon bacillus). (3) *Abdominal tenderness* and *board-like rigidity*. (4) *Vomiting*—often projectile, copious, either black from extravasated blood, or offensive, thin and yellow—from regurgitated intestinal contents. (5) *Obstipation*, laxatives by mouth are vomited, enemas expelled or retained, no flatus is expelled except in streptococcic or pneumococcic peritonitis when there may be diarrhea. (6) *Pulse* is *rapid* (110 to 115), small

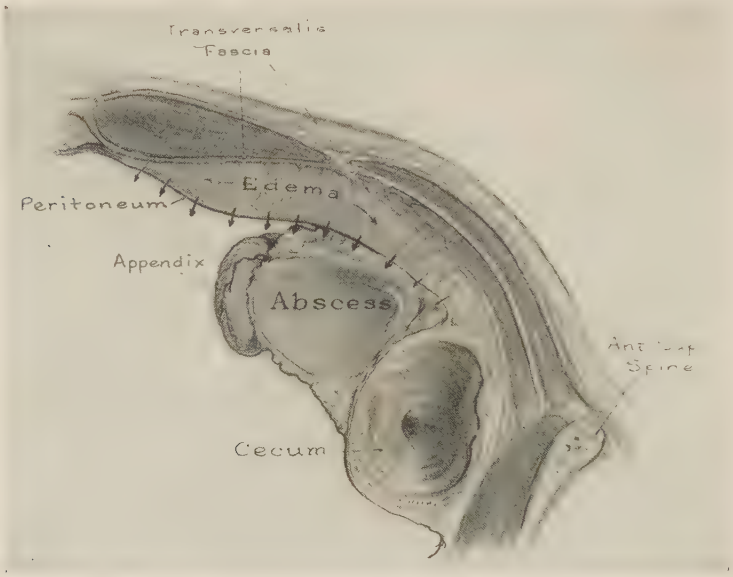


Fig. 763.—Appendiceal abscess, walled off by the adherent cecum and appendix, showing marked watery edema of the preperitoneal connective tissue.

volume, high tension, and wiry. (7) *Temperature* 100° to 103° F. or higher (fever may be absent in the aged and cachectic). (8) *Tongue dry, coated*, or *red*, becoming brown and crusted with sordes. (9) *Urine decreased in amount;* urination may be frequent, with pain and hematuria from contiguity of infection. (10) *Blood-leukocytosis* 18,000 and upward (may be absent in localized or very virulent peritonitis, or in patients with poor resistance), showing 75 to 90 per cent. polymorphonuclear neutrophils.

D. **Terminal Stage (General Toxemia).**—*Facies hippocratica*, the eyes are sunken, the nose sharp and gray, the temples and cheeks collapsed and livid, the expression drawn and anxious. The forehead is cold and wet from sweat. The *skin* of the hands and face is livid or cyanotic, wrinkled, shrunken, and wet with clammy sweat. The *pulse* is running, weak, 140 to 200. *Inflammatory ileus* is usual, or, especially in streptococcic (puerperal) and pneumococcic forms, a septic diarrhea may occur. The mind is clear, or an active delirium requiring

restraint may be present. Respiration is shallow, rapid, and labored. The temperature by mouth is 101° to 103° F.; by rectum, 105° to 108° F.

Diagnosis is to be made from: (1) Intestinal colic from plumbism, or acute enteritis; (2) gastric crises of tabes; (3) other forms of ileus; (4) peritoneal hemorrhage, ectopic pregnancy, acute pancreatitis, typhoid; (5) acute pneumonia or diaphragmatic pleurisy; (6) ovarian tumor with twisted pedicle. A rectal or vaginal examination should be made in all cases. Other factors in diagnosis are considered under appendicitis, abdominal injury, perforated gastric and duodenal ulcers.

Prognosis.—(1) In spreading forms without operation death usually occurs in from two to six days. (2) In infants, the aged, nephritic, diabetic, and obese, there is a high mortality. (3) Operations for diffuse purulent peritonitis within twelve hours of the onset give a favorable, between twelve to forty-eight hours a serious, and after forty-eight hours a grave prognosis. (4) Acute diffuse puerperal, pneumococcic, and streptococcic types are usually fatal; the pure B. coli type is grave. Mixed coli and staphylococcic has a fair, and gonococcic peritonitis a good prognosis. The danger of peritonitis is increased by coexisting pregnancy (difficulty in localization and drainage) and intraperitoneal blood-clot. Very important is the previous environment of the bacteria. The dose and virulence may be tremendously increased by previous growth in blood-clot or dead tissue. In the necrotic tissue of malignant tumors, streptococci grow and acquire virulence. Protected in blood-clot or dead tissue, bacteria that otherwise would be destroyed and removed, multiply rapidly, acquire virulence, and then flood out in a continued stream to overwhelm the peritoneal defenses. Likewise an otherwise effective peritoneal resistance to severe bacterial invasion may fail, while sterile bile, urine, antiseptics, or even physiologic saline solution enters the peritoneal cavity.

Simple penetrating wounds of the peritoneum without visceral injury rarely cause fatal peritonitis.

Order of virulence, from the least to the most dangerous: (1) Gonococcic infection through tubes; (2) gall-bladder infection; (3) perforation of appendix; (4) perforation of stomach, duodenum, or jejunum; (5) perforation of ileum or colon; (6) perforation of typhoid ulcer; (7) puerperal infection; and (8) acute pneumococcal infection in childhood; (9) secondary purulent peritonitis from blood-stream infections.

The *high average mortality* of 70 to 90 per cent. for diffuse purulent peritonitis, of the older surgeons, has been reduced to 5 to 16 per cent. by: (1) Earlier operation; (2) reduction of operative traumatism; (3) Ochsner treatment in certain cases; (4) better anesthesia; (5) rational postoperative treatment.

Decreased resistance to peritonitis is found in young children and in patients over thirty-five years of age. Obesity, diabetes, jaundice, and associated infections as pneumonia, typhoid, or toxemia from ether, chloroform, narcotics, or nitrous oxid lower the resistance.

Operative manipulation is, as Ochsner emphasized, especially dangerous during the intermediate inflammatory period, usually beginning about forty-eight hours after the onset of symptoms and continuing until localization occurs.

Death occurs from two great causes: (1) An ileus with high intestinal toxemia,

and (2) infection that has spread without the peritoneal cavity, especially into the blood-stream.

Ominous Symptoms.—(1) Pulse-rate after twenty-four hours persisting above 120, and tending to increase; (2) persistent obstipation, absence of peristalsis, or the onset of toxic diarrhea; (3) cyanosis, failing circulation; (4) stercoraceous or black vomit; (5) rigors and chills indicate development of new hematogenous septic foci (pneumonitis, pylephlebitis, subphrenic abscess, hepatic abscess, etc.); (6) active delirium.

Treatment.—The treatment of acute primary septic peritonitis, early stage, is immediate operation with the removal or occlusion of the source of infection, the least exposure or manipulation of the peritoneum, and the least possible disturbance of the peritoneum and protective peritoneal exudate. In the preoperative period, an ambulant treatment, the administration of water, broths, soft foods, and especially cathartics are harmful.

Food and laxatives in peritonitis favor leakage, prevent localization, spread infection, increase temperature, pulse, nausea, vomiting, tympany; invite obstruction, ileus, jejunal toxemia, and are responsible for many deaths. No liquid or solid food should be given by mouth either before or after operation until safe localization has occurred, as shown by free spontaneous passage of flatus and feces with stabilization of the pulse.

Operation is delayed: (1) When the diagnosis is in doubt, (2) pending the arrival of surgical aid; (3) in case of overwhelming pneumococcic and streptococcic peritonitis; (4) in secondary general peritonitis that is a part of a general sepsis, until there is clear evidence of localization; (5) in certain cases during the intermediate very septic period, except in children, the aged, or in cases of perforation with rapid or continued leakage; (6) in acute gonococcic peritonitis, operation is unnecessary though not dangerous.

Ochsner treatment is intended to produce localization by peristaltic rest in the dangerous intermediate period, after which an operation completes the treatment. It consists of: (1) Fowler position; (2) absolute rest; (3) no food or drink by mouth; (4) nutrient enemas or enteroclysis (best omitted); (5) hypodermoclysis; (6) opiates if required to check peristalsis and relieve pain; (7) operation when temperature and pulse are stabilized and there is evidence of efficient localization (usually ten to twenty-one days after beginning treatment). The older methods of arresting peristalsis in peritonitis depended on the administration of large doses of opium (*Alonzo Clark treatment, William Pepper treatment*).

Ochsner treatment is not to be used: (1) In first forty-eight hours, except when in doubt, while making a diagnosis, or when surgical aid is not available; (2) in active or progressive internal leakage; (3) in infants and the aged.

It gives a mortality of about 16 per cent. (Ashhurst). It is advised for the surgeon of limited facilities or skill in operating.

Operative Treatment.—A. *Anesthetic:* For those skilled in its use, spinal anesthesia is ideal, giving perfect relaxation with minimal toxemia. Ether and chloroform produce parenchymatous changes in the organs, reduce resistance to infection, and favor certain complications. Nitrous oxid-oxygen, ethylene, and especially local anesthesia, skilfully used, have not the same objections and often are to be preferred. Yet for the individual patient, if either ether or chloroform

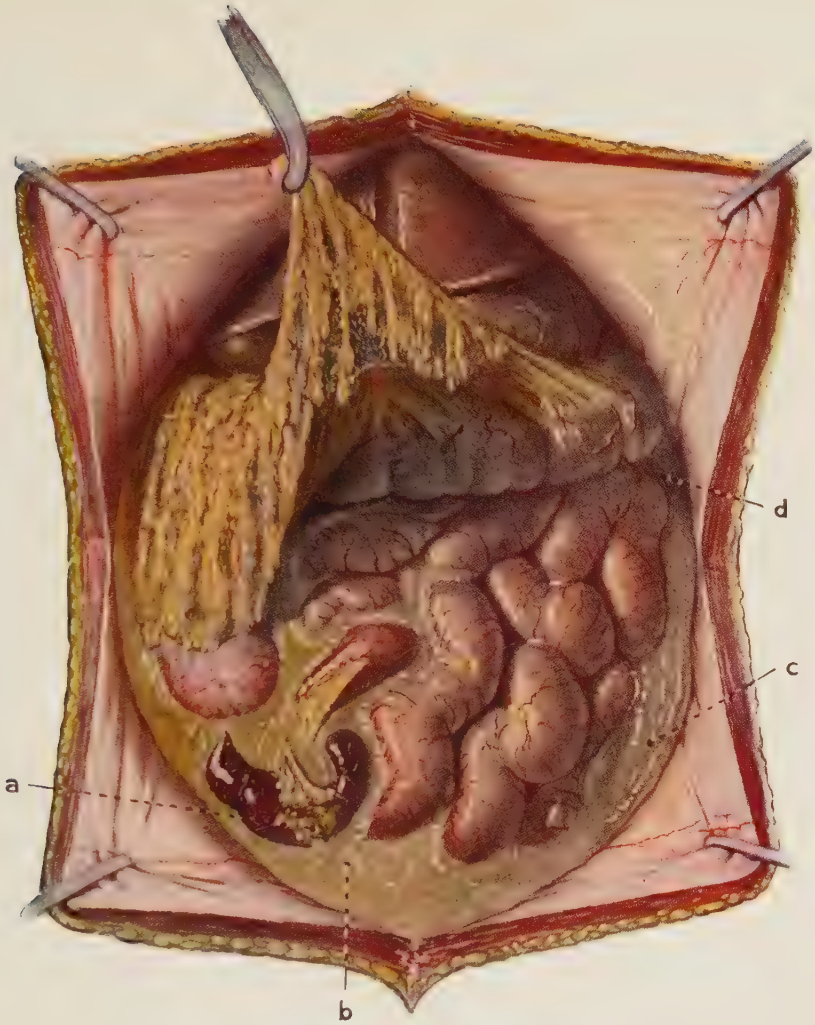


Fig. 765.—Type of diffuse purulent peritonitis from perforative appendicitis of forty-eight hours' duration, representing the greatly aggravated condition from treatment by laxatives, enemas, and nourishment by mouth. (a) Perforation in middle third of intensely inflamed and seminecrotic appendix with adjacent patches of adherent, greenish organized exudate. (b) Pus adjacent to appendix and in pelvis containing many colon bacilli, some intracellular. (c) More distant seropus containing fewer bacteria that are largely intracellular. (d) Turbid serum in upper abdomen containing a few dead bacteria, leukocytes, lymphocytes, and phagocytic endothelial cells. The partially adherent omentum has been separated and raised. Had the peristalsis not been stimulated by improper treatment, it is probable that the appendix would have been isolated by omental and other adhesions with localization of the abscess. In this type the solid seminecrotic exudate and the many dead pus-cells indicate the need of limited drainage. A short muscle-splitting incision, a brief five or ten minute operation with simple ligation and removal of the appendix and a cigarette-drain to the appendiceal stump and rubber-tube drain to the bottom of the pelvis gives a high percentage of recoveries. With large or multiple incisions and unnecessary manipulation, as by the introduction of the hand into the abdomen, attempts to remove pus by irrigation or sponging, the use of the purse-string suture and multiple drains between the intestinal coils, the operative mortality is high. With the simple technic, persistent postoperative fistulæ are almost unknown.

by giving better relaxation enables the operation to be done quicker and with less intraperitoneal traumatism, it should be preferred. The use of a local anesthetic directly upon the peritoneum is harmful, decreasing resistance to infection and favoring bacterial dissemination. In diffuse peritonitis, it is often difficult to secure adequate relaxation of the rigid abdominal wall by local anesthesia.

B. *Operation.*—The incision should be over the causal lesion, leaking openings should be occluded or closed, and the cause of the peritonitis removed or isolated. The shortest incision, the briefest operation, and the least possible intra-abdominal manipulation should be used. Foreign bodies should be removed or isolated, but liquid or plastic exudate should not be removed, diluted, or disturbed any more than is absolutely necessary. Seropus or thin fresh pus is bactericidal, antitoxic, phagocytic. Old, thick, odorous pus with necrotic particles contains many dead cells, and may be absorbed with difficulty. It should not be washed away, but given a chance to escape by a simple tubular drain. Organized greenish or yellowish exudate should be drained, but not dislodged.

Operative manipulation is very dangerous if the infection is from the Streptococcus hæmolyticus (acute type), the pneumococcus (acute fulminant type), or the Bacillus pyocyaneus; *dangerous*, if from the Staphylococcus aureus, the streptococcus, or the colon bacillus; but is *not dangerous* when the causal organism is the tubercle bacillus, the gonococcus, the pneumococcus (chronic form) or the Staphylococcus albus.

Operative manipulation is also especially dangerous, as Ochsner has emphasized, during the intermediate inflammatory period usually beginning about forty-eight hours after the onset of symptoms.

The abdomen is to be closed without peritoneal drainage, unless there is solid necrotic material or old dead pus in the cavity, when peripheral drains of the soft cigarette type, or soft rubber tubes, are carried to the bottom of the cavity to be drained. Drainage of the general peritoneal cavity is impossible. Drains usually are walled off within four hours. Multiple drains, especially those between the intestinal coils and to various parts of the peritoneal cavity, are unnecessary and harmful.

Drainage is indicated: (1) When necrotic or foreign solid matter is left in the abdomen, as pus-clot, blood-clot, gangrenous tissue, alimentary contents, or fecal concretions. Blood-clot, dead tissue, foreign bodies, and hemorrhage are deadly by incubating bacteria and spreading peritonitis, and should be removed, isolated, or occluded by appropriate gauze packing. (2) To prevent further leakage into the abdominal cavity and (3) in hemorrhage or for oozing surfaces.

Types of Drains.—1. Tube drains, small or large tubes of rubber or glass, are used for large exudates, as old pus, gastric or intestinal contents, bile, pancreatic juice, and the like. The tubes are introduced as required (but not between intestinal coils): (a) To the area of abdominal infection through the wound; (b) through a suprapubic stab to the culdesac of Douglas; (c) through a loin incision to the posterior peritoneal recesses, as in pancreatitis.

2. Cigarette or split-tube drains are used: (a) For smaller quantities of exudate or other fluid; (b) to guard points of ligature or suture.

3. Mikulicz's drains or large packs are used: (a) To isolate or wall off septic

or leaking areas in the abdomen; (b) to produce adhesions about points liable to perforation or rupture (two-stage operation for intra-abdominal abscess, gangrenous hernia); (c) to control bleeding, especially large oozing surfaces. The Mikulicz drain is introduced through an anterior abdominal incision or through the posterior vaginal culdesac.

Removal of Drains.—(1) Small drains for primary oozing or exudate are removed in twenty-four to forty-eight hours; (2) large tube drains by fifth day if possible; (3) large packs are removed in portions between the fourth and eighth days, avoiding excessive traction or evisceration. Drains should not be replaced without definite indication. In streptococcic infection, the removal should be delayed until the ninth to the twelfth day, awaiting firm adhesions and safe localization.

Dangers of Drains.—(1) Drains carry infection from skin to depth of wound; (2) the intestinal wall may project into openings of the drainage tube and be strangulated, become necrotic, and perforate (rotate tube daily); (3) constant pressure of the tube may cause perforation of a viscus or blood-vessel (rotate and gradually withdraw day by day); (4) drains against suture lines favor separation and fistula (interpose omentum), and gauze left against intestine or bladder may cause perforation in fourteen days or more.

Antiseptics in peritoneum are harmful. Dakin's solution in the free peritoneal cavity causes fatal destruction of the mesentery and omentum. While not advocated, recovery has followed the use of ether and tincture of iodin in the acutely inflamed peritoneum. To prevent skin-infection and secondary wound-abscess in subcutaneous fat, the wound may be dusted with sterilized boric acid *after the peritoneum has been closed* or, better, the skin and fat left open for delayed closure.

For *jejunal toxemia*, or high intestinal obstruction from inflammatory paresis, three methods of treatment have been suggested: (1) A high enterostomy; (2) a jejunocolostomy with or without a cecostomy, as suggested by Handley, and (3) Costain's lymphaticostomy, or the drainage of the thoracic duct in the neck. The second method is too severe. The third has not yet fulfilled the promise of the interesting laboratory experiments. The first, the introduction of a small tube for drainage in the upper small intestine, is often life-saving and should not be forgotten.

Preoperative and Postoperative Treatment of Peritonitis.—(1) Absolute rest in the most comfortable position (Fowler's position); (2) no liquid or food by mouth or rectum until localization occurs (peristaltic rest); (3) maintenance of body fluids (water), chlorids (salt), fuel (glucose), as required, by continuous or intermittent subcutaneous injection; (4) local abdominal support (bandage), with guarded application of heat, cold, or alcohol compresses; (5) opiates only when indicated, as for the violent initial pain or shock, to enable transportation of the patient, or for the immediate postoperative pain. Opiates should not be used for pain due to distention or dilatation, tympany, nausea, urinary retention, or septic delirium.

In the postoperative treatment of peritonitis the continued use of narcotics, the use of strychnin, eserin, pituitrin, or the early use of water, food, and laxatives by mouth may do great harm.

Localization is indicated by: (1) Soft flat abdomen with definite local mass; (2) stabilization of pulse and temperature; (3) absence of pain, tympany, or temperature on giving liquid or light food by enema or mouth.

Proctoclysis and *enemas in peritonitis* although much less harmful than liquids by mouth, increase peristalsis (delay localization, increase leakage, bacterial dissemination, and pain), irritate the lower bowel (unbalance bacterial equilibrium in colon; favor bacterial growth), provide a fecal decoction and bacterial culture for absorption, and have uncertain and variable rate of absorption. Why replenish the depleted body fluids by uncertain doses of manure water, when hypodermoclysis affords a positive ample supply of clean sterile fluid for the body need?

Pneumococcus Peritonitis.—Varieties: (a) Primary, not associated with pneumococcic lesions elsewhere in the body; (b) secondary, where a pre-existent focus is present in the body.

May be localized or diffuse; and hyperacute, acute, or subacute.

Pathology.—Turbid sticky serum first exudes, turning into milky pus which is odorless and contains numerous fibrin (pus) clots. The peritoneum is injected, covered in places by plaques of somewhat adherent greenish fibrin. In the localized form there is a walled-off abscess, usually on one side of the lower abdomen, which enlarges and often points at the navel. In the diffuse type, free pus is found throughout the abdominal cavity.

Infection occurs through: (1) The genital organs of the female; (2) the bloodstream; (3) the lymphatics; (4) the gastro-intestinal tract.

Etiology.—*Childhood*, usually between the ages of three and seven years; occasionally in infancy. *Females* form 66 per cent. of the patients. *Poor hygienic surroundings:* Children of the slums of large cities. The pneumococcus usually enters through the vagina.

Symptoms.—1. *Circumscribed Form:* The onset is sudden, with acute pain which spreads over the abdomen and is associated with high fever, profuse vomiting, persistent diarrhea, and, at times, bloody stools. After seven to ten days the infection becomes localized, the general symptoms lessen, and a mass due to abscess formation is felt to one or other side of the lower abdomen (*abdominal empyema*). If not opened, the abscess after a number of weeks may empty spontaneously, usually through the navel or, more rarely, into the bowel, vagina, or bladder.

2. *Diffuse Form:* A mild angina or vulvovaginitis usually precedes the attack. The onset is sudden with benign facial expression, high fever and leukocytosis, herpes labialis, intense abdominal pain referred to the navel, prostration, copious diarrhea (frequently bloody), and persistent, often projectile vomiting; followed by delirium, sordes, apathetic facies, flushed cheeks, cyanosis, cold extremities, and usually death within a few days.

There is moderate distention and a doughy feel to the abdomen, and a *striking absence of local tenderness or rigidity.* The leukocytes number from 10,000 to 50,000 per c.mm., over 90 per cent. being polymorphonuclears.

Diagnosis.—The sudden violent onset (with great prostration, intense toxemia, marked nausea, vomiting, and diarrhea), absence of local pain or muscle-spasm, rigidity, or tenderness, with some increased tension and tympany, diar-

rhea, drowsiness, stupor, and rapid course are characteristic and differentiate the condition from acute appendicitis, a ruptured viscus, typhoid fever, and tuberculous peritonitis. Appendicitis usually occurs after the age of six, pneumococcic peritonitis under the age of six. A very high polymorphonuclear count suggests the pneumococcic infection. The diagnosis is proved by injecting aspirated peritoneal fluid into a mouse. This causes death in six hours, with the presence of pneumococci in the body fluids. The evidence of a preceding pneumococcic vaginitis may confirm the diagnosis.

Mortality.—In diffuse forms, 80 per cent. or more; in localized forms, 10 per cent.

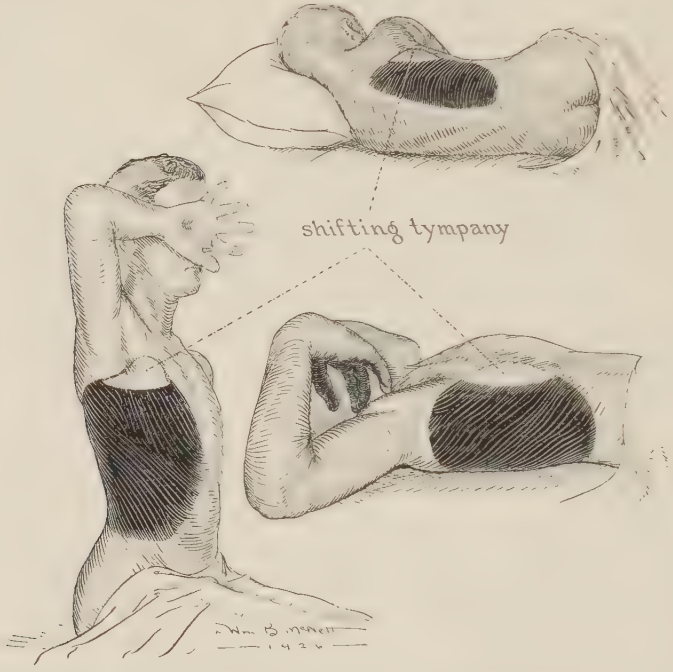


Fig. 766.—Right subphrenic abscess following purulent appendicitis showing area of dulness and the shifting tympany from the large gas-bubble. The gas was formed by the colon bacilli. Recovery after incision and drainage.

Treatment of the diffuse form is discouraging. The patient usually dies despite any form of treatment. Complete rest in the Fowler position with alcoholic compresses over the abdomen, and supportive treatment with heat, fluids subcutaneously, saline and glucose intravenously, and antipneumococcus serum. If the patient does not die before localization has occurred, the abscess is to be drained. In certain types of the diffuse form, simple incision and drainage under local anesthesia or ethylene, without intra-abdominal traumatism, may be used to relieve the intra-abdominal tension and to reduce the toxic absorption.

Subphrenic abscess is a localized purulent collection directly below the diaphragm.

A. **Intraperitoneal Forms.**—1. Right Anterior: Thirty-three per cent. The

diaphragm is above and the liver below, the falciform ligament on the left, the right lateral ligament posteriorly. Adhesions between the transverse colon, the diaphragm, and the lower edge of the liver limit the abscess anteriorly. The pus may extend around the edge of the lateral ligament into the right posterior pouch, and into the right loin below the liver. The liver is fixed by adhesions and not displaced.

Etiology.—Infection from the appendix, a perforated gastric or duodenal ulcer or, rarely, abscess of the liver.

The diaphragm is elevated and immobilized, the exploring needle not immobilized. A large gas-bubble may give a shifting area of tympany in the right hypochondrium. Often there is consolidation of the base of the right lung, or tympanitic swelling in the right hypochondrium.

2. Left Anterior: Twelve per cent. (in the perigastric or perisplenic pouch). The pus lies between the liver and stomach below and diaphragm above, with the spleen to the left, the falciform ligament to the right, left lateral ligament behind.

Etiology.—Perforation of gastric ulcer. An abscess containing gas is found in the left hypochondrium.

3. Right Posterior: Fifty per cent. (in the subhepatic or right kidney pouch). The pus extends from between the liver and diaphragm above, around the folds of the coronary ligament, to the right kidney and transverse colon below.

Etiology.—Pyogenic infections of the appendix, duodenum, or stomach. The abscess lies below the right costal margin, and extends to the right iliac fossa.

4. Left Posterior: Four per cent. (in the lesser peritoneal cavity). The foramen of Winslow is closed by adhesions.

Etiology.—Perforation of the posterior wall of the stomach from ulcer or cancer, infection from the pancreas or biliary ducts. The swelling occurs behind and below the stomach, and may simulate a pancreatic cyst.

B. Extraperitoneal (On the Bare Area of the Liver).—1. Right.—Between the layers of the right coronary ligament. The pus depresses the liver, extends back to the region of the right kidney, and anteriorly lies between the folds of the falciform ligament.

Etiology.—Infection of hepatic, biliary, right renal, pancreatic, duodenal, or thoracic origin. The liver is displaced downward, and the abscess points in epigastrium or right loin.

2. Left (Rare).—The pus lies between the layers of the left coronary ligament.

Etiology.—Infection from the left kidney, gastric ulcer, lumbar Pott's disease, or a left empyema. There is evidence of consolidation of the left base. The abscess points in left loin.

Pathology.—These abscesses usually are due to Bacillus coli or staphylococci spreading along or beneath the peritoneum.

Etiology.—*Males*, four to one. *Age*, chiefly between twenty and thirty years, but may occur between the ages of ten and seventy. The abscess may be secondary to a ruptured gastric or duodenal ulcer, or gastric carcinoma (33 per cent.); to appendicitis, 16 per cent.; to hepatic disease, 16 per cent.; and parturition,

pyemia, infarction of spleen, empyema, pneumonia, pulmonary abscess, Pott's disease, cholangitis, cholecystitis, septic nephritis, abscess of the prostate, hydatid cyst, or crushing or open wound.

Symptoms are those of the causal disease, as gastric ulcer, appendicitis, cholecystitis, followed in most intraperitoneal forms by sudden onset with sharp pain in the abdomen, lower chest, or back. In most extraperitoneal cases and those from appendicitis, the onset is insidious. A *latent period* follows, which may last from seven to ten days.

With a fully formed abscess there is: (1) An area of dulness with movable gas-bubble (from bacteria or perforation), abdominal mass, and rigidity; (2) a remittent temperature, reaching 102° to 104° F. in the evening; (3) sweats (rigors and chills rare and indicate ominous complication); (4) sallow, muddy complexion; (5) leukocytes average 17,000, but may be of normal number; (6) loss of weight, average 33 pounds; (7) thoracic symptoms, cough, pleural friction

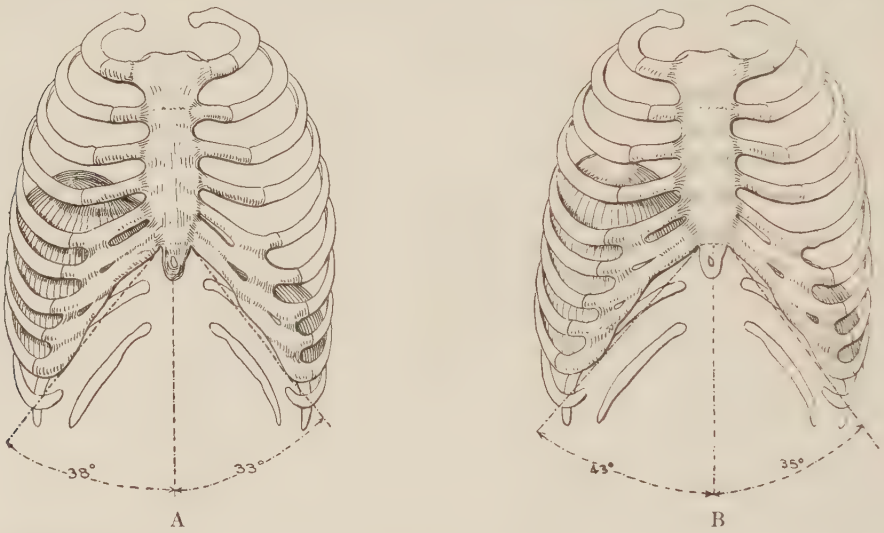


Fig. 767.—Widening of costal angle in subphrenic abscess showing the increase of the right costal angle on (A) expiration (B) inspiration.

followed by evidence of effusion of serum or later pus; (8) heart is raised, but not displaced laterally; (9) diaphragm is elevated, immobile, and abnormally convex above; (10) unilateral enlargement of the thorax; (11) liver is usually fixed, and does not move with respiration. Roentgenogram shows greater depth of liver shadow, a raised convex diaphragm, and a gas-bubble shifting on movement.

Diagnosis.—The diaphragm is partly immobilized; the exploring needle through the diaphragm oscillates with respiration, and may withdraw serum superficially (from pleura), and pus deep (from below diaphragm). Pleural effusions flatten and depress but do not immobilize the diaphragm, displace the heart laterally, do not fix the liver, or cause oscillation of exploring needle. Hepatic abscess moves with respiration.

Prognosis.—The abscess may point in hypochondrium, epigastrium, or loin. It may rupture in: (a) Stomach; (b) pleura; (c) bronchus; (d) peritoneum, and

(e) the intestine. The mortality without operation is 70 per cent.; with operation, 30 per cent. Rupture into the peritoneum or pleura is usually fatal. The average duration of symptoms is four and one-half months. Subphrenic abscess is rarely recognized early, and often persistent fistula and invalidism follows.

Exploration.—A large exploring needle is introduced from 2 to 8 cm. (from thoracic side, never through peritoneal cavity). It should be entered in the tenth, ninth, eighth, or seventh interspace, first in the scapular and then in the mid-axillary line, through the diaphragm (noting oscillations of the needle). Exploration is dangerous, and is only to be employed immediately before operation.

Treatment.—Local or paravertebral anesthesia should be used. The abscess should be evacuated and drained as soon as diagnosed:

1. *Transpleural Route.*—A rib not higher than the seventh is resected, the diaphragm sewed to the upper edge of the wound, closing off the pleura; the diaphragm incised, and the cavity drained by tubes and gauze.

2. *Abdominal route*, through the anterior abdominal wall or loin, should be used for low localized collections. Posterior operations give a lower mortality, but are not always feasible.

Chronic Peritonitis.—Chronic peritonitis may be adhesive or proliferative, tuberculous or actinomycotic.

Chronic Adhesive Peritonitis (Intra-abdominal Adhesions).—*Varieties.*—Local, pelvic, upper abdominal, visceral, parietal, general chronic, general hemorrhagic.

The adhesions of fibroconnective tissue covered by endothelium appear as strings, bands, sheets, or a dense fusion of viscera.

Pathology.—Adhesions rapidly occur after mechanical, chemical, or parasitic irritation of the peritoneum. Plastic adhesions walling off irritated areas form in from one-half to three hours, and in one week become organized into fibroconnective tissue. The adhesions, if the irritation is not continued or the surface destruction too great, tend to disappear rapidly. Endothelium proliferates, and covers the denuded surfaces; adherent viscera are gradually pulled apart by peristaltic and other abdominal movements, transforming broad adhesions into bands and cords which (if not too dense) rupture, atrophy, and are absorbed. Adhesions, following suture of peritoneal surfaces, are weakest at the end of a week, when they may be separated by the pressure of a finger; while at the end of two weeks, fibroconnective-tissue organization is so complete that intraperitoneal separation by the finger is difficult, and sharp dissection may be required.

Etiology.—(1) Operative traumatism, especially rough manipulation with packing, sponging, handling, and drainage; (2) infection from tubes and ovaries; (3) chronic infection of the intestinal tract, appendicitis, ulcer of the stomach or duodenum, diverticulitis, colitis; (4) chronic hepatitis, cholecystitis, splenitis; (5) inflammation in hernial sac; (6) foreign bodies, including gall-stones, fecal concretions, drains, instruments; even Cargile membrane, paraffin oil, and other foreign substances used to prevent adhesions. Adhesions form more slowly in extreme cachexia and anemia.

Symptoms.—(1) Usually absent; (2) abdominal pain, especially in the neu-

rotic; (3) distortion of the abdominal wall; (4) interference with alimentary function, producing dyspepsia, constipation, meteorism; (5) ileus from angulation (kinks), torsion, pressure produced by cords, bands, or masses of adhesions; (6) circulatory obstruction, usually from cords, bands, or torsion, with secondary necrosis and gangrene.

Prophylaxis.—Gentleness and delicacy in operative technic. Avoidance of rough prolonged operative manipulation, undue exposure of the peritoneal surface, excessive sponging, packing, overuse of drains. Denuded surface should be covered, and all foreign bodies, infected useless organs, and other sources of chronic irritation removed.

Diagnosis.—Abdominal scar that shows evidence of infection, drainage, or crude surgical technic. Distortion of the abdominal wall on movement, asymmetric distention or peristalsis. Roentgen study.

Treatment.—Reoperation for abdominal adhesions is to be considered only when definite symptoms are present not relieved by diet, abdominal support, massage, enemas, and colonic irrigation. Adhesions often re-form after operative separation. With signs of acute intestinal obstruction from intra-abdominal adhesions, immediate abdominal exploration is indicated.

Special Varieties.—The following types have been described: 1. *Ideal band*, quadrilateral or triangular in shape, extends from the right iliac fossa to the convex border of the terminal portion of the ileum, producing kinking and rotation of the bowel on its long axis.

2. *Splenic pericolic adhesion*, with kinking of the splenic flexure (*Payr's disease*).

3. *Mesocolic adhesion*, with angulation and approximation of the two limbs of the sigmoid.

4. *Jackson's membrane*, a thin reflection of serous membrane binding down the ascending colon and cecum to the posterior abdominal wall, from (a) a congenital pulling down of a peritoneal fold by the cecum during its rotation; or (b) inflammatory disease either before or after birth. The membrane may interfere with the normal action of the colon.

5. *Lane's kink* or *Price's elbow*, an angulation of the lower ileum from a reflection of peritoneum near the cecum. Lane's kink also refers to an angulation in the jejunum. With logic not always convincing, the angulation has been given as the cause of intestinal stasis, intestinal toxemia, malaise, depression, drowsiness, subnormal temperature, loss of weight, thin wrinkled dusky skin, excessive perspiration, ptosis of the viscera, secondary arthritis deformans, chronic mastitis, goiter, epilepsy, abdominal distention, pain and borborygmi, obstipation, and occasional attacks of diarrhea.

Diagnosis.—By the general symptoms, the abdominal contour, and by fluoroscopic and radiographic examination.

Treatment.—If there is very definite indication of mechanical obstruction, this should be relieved by operation. Great care should be taken to avoid operation when there is only neurosis or hysteria, or without careful trial of non-operative measures, including diet, exercise, enemas, and colonic lavage.

Tuberculous peritonitis, a chronic form due to the Bacillus tuberculosis, is chiefly a disease of children and young adults, but occurs at all ages. It is more

frequent in females, infection often occurring through the fallopian tubes. It is often a milk-borne infection. Under one year, tuberculosis is usually a generalized disease (acute miliary tuberculosis).

Mode of Infection: 1. *Through alimentary tract:* Milk and milk products from tuberculous cows. The bovine bacillus is found in 25 to 30 per cent. Swallowed sputum. There may be a primary localization of the tuberculosis in the appendix, intestine, or especially in the mesenteric lymph-nodes.

2. *Through genital tract:* From the fallopian tubes, through a pre-existing tuberculous salpingitis or metritis. The leakage of the bacilli into peritoneum tends to continue over a long period of time, as the fimbria do not occlude as in gonorrheal salpingitis. In the male the peritonitis may originate from a tuberculous vesiculitis.

3. *Through blood and lymphatics:* Part of general miliary tuberculosis.

4. *From respiratory tract* with involvement of the pleura and pericardium (polyorrhomenitis). A terminal tuberculous infection occurs in cirrhosis of the liver and tubercles may be found on ovarian tumors or in a hernial sac. The tubercles are usually found along the blood-vessels.

Varieties of Tuberculous Peritonitis:

1. *Wet* or *ascitic type* is characterized by much turbid serum, the visceral and parietal peritoneum being thick, edematous, brittle, and studded by miliary tubercles. It is the mildest form, 60 per cent. of the patients recovering after a simple celiotomy. Occasionally it becomes localized. The omentum is thick, infiltrated, often forming a palpable broad transverse roll across the upper abdomen.

2. *Fibrous* or *adhesive type* is characterized by many adhesions and little free fluid. Operation is difficult, and the condition serious.

3. *Caseous Ulcerative Type.*—Caseous masses or abscesses and dense adhesions form between the intestinal coils. Fecal impaction and intestinal fistulæ are common. The operative treatment is difficult and unsatisfactory, and the patients usually die.

4. *Lymphoglandular Type* (Mildest), *Tabes Mesenterica.*—Fifty per cent. of children show some enlargement of the mesenteric lymph-nodes, often tuberculous. The mesenteric lymph-nodes are enlarged, hyaline, or caseous and, if of long standing, calcareous.

Tuberculosis is a common cause of free peritoneal fluid and of peritoneal adhesions in childhood.

Symptoms.—(1) Latent; (2) insidious (most common), or (3) with acute onset, suggesting a mild appendicitis or ileus.

General.—In the early stages the patient may appear plump and well-nourished, but as the disease progresses there is weakness, loss of weight, pallor and tachycardia. The evening temperature is 99° to 101° F. or subnormal, or in acute forms 103° to 104° F. Tympanitis, nausea, and vomiting are often absent, constipation is usual, diarrhea occurs when there is ulceration of the intestines. Pigmentation, abdominal or general but sparing the buccal mucosa, is often seen. A neurosis is not unusual from the chronic toxemia.

Local.—The abdominal distention is progressive, and may become very marked in the ascitic form. There is shifting dulness in flanks, and a fluid wave.

Tumors formed by the transverse roll of thick infiltrated omentum across the upper abdomen, by infiltrated intestine or the thickened parietal peritoneum, are usual. An associated tuberculosis of the tubes, ovaries, or appendix is common. Occasionally the uterus is involved and is caseous. In tuberculosis of the tubes, the fimbriated ends tend to remain open and discharge the bacteria into the abdominal cavity, with constant reinfection. Pain and tenderness are usually slight, and true muscular rigidity absent.

Diagnosis.—Tuberculous peritonitis is the most common cause of ascites in children. Abdominal distention by fluid, with nodular masses in the abdomen, wasting, slight evening fever, and a tendency to diarrhea in a person under twenty, suggests tuberculosis. Adjacent lymphadenopathy, and roentgenologic and other evidence of tuberculosis of the lungs may be associated. Free abdominal fluid found on opening the abdomen, without other cause, suggests tuberculosis. In Banti's disease the anemia is more marked, and the enlarged spleen and cirrhotic liver are to be differentiated from a rolled-up and thickened omentum or intestinal mass. An ovarian cyst has a regular well localized outline, with central anterior and not shifting dulness, and there is no associated increase in temperature. In adults, cirrhosis of the liver and diffuse carcinomatosis of the peritoneum should be differentiated.

Prognosis.—The outlook is unfavorable in patients under two years or if there are intestinal fistulæ, an associated enteric tuberculosis, or serious involvement elsewhere in the body. Sixty per cent. of patients with the ascitic type recover; and with tabes mesenterica and the mild plastic type, recovery is usual. Prognosis is improved by removal of diseased tubes and appendix. The fluid usually recurs after a simple aspiration.

Treatment.—1. *Rest*, fresh air, ample assimilable food. Exposure of the abdomen to sunlight or the quartz-light is of great value, and often curative. Carefully supervised injections of tuberculin in graduated doses are useful in certain cases.

2. *Operation.*—In the ascitic form, 50 to 60 per cent. recover simply from opening the abdomen and exposing the viscera to air; while 60 to 70 per cent. recover if the associated infected tubes or appendix are also removed. The additional value of injecting oxygen between the intestinal coils, or dusting them with iodoform, has not been proved. Drainage should not be used, as it favors a dangerous mixed infection.

Fibrous Form of Tuberculous Peritonitis.—Characterized by irregular indurated areas in the abdomen without ascitic distention. The patient is quite emaciated, and there is evening fever and, frequently, vomiting.

Prognosis is grave, and operation usually is not satisfactory.

Treatment.—Exposure to sunlight, quartz-light or the Roentgen ray, overfeeding, absolute rest, and fresh air. Tuberculin is of little value. In operating, the intestines must be handled with the greatest care to avoid laceration and the formation of secondary fecal fistula.

Caseous Form of Tuberculous Peritonitis.—The patient is emaciated and of poor resistance, and has caseous masses and cold abscesses between the loops of bowel. Occasionally it is necessary to evacuate these accumulations. Persistent intestinal fistulæ or sinuses of the abdominal wall occur spontaneously or follow operation.

Prognosis is unfavorable.

Treatment.—General roborant treatment, rest, exposure of the abdominal wall to sunlight, quartz-light, Roentgen ray, or radium. The sinuses should be swabbed with 90 per cent. phenol followed by tincture of iodin, and filled with Beck's paste (50 per cent. bismuth subnitrate in white petrolatum) or Morrison's bipp (bismuth, iodoform, petrolatum, paste). For superficial local lesions, sterilization by saturated zinc chlorid solution, followed by excision and suture may be tried. The local application of nitrate of silver should be avoided in all forms of surgical tuberculosis.

Actinomycosis follows contact with grains, cattle, or their products, and in the abdomen usually involves the ileocecal region with a dense infiltrating mass that enlarges and breaks down, discharging a yellow watery pus with the minute gray or sulphur-yellow granules (chestnut-burr appearance under the microscope) containing the mycelia and spores of the streptothrix. Adhesions form to the abdominal wall, and abscesses and sinuses follow.

Symptoms.—A firm fixed mass in the lower right quadrant, which tends to enlarge and to form sinuses. There is slight fever, and only moderate local pain.

Diagnosis is difficult until a specimen of pus or tissue is examined.

Prognosis should be guarded. The mortality of abdominal actinomycosis is 60 per cent. and, if the lungs are also involved, it is 100 per cent. There is marked tendency to recurrence after apparent cure. If two years have elapsed without recurrence, the patient may be considered cured.

General treatment consists in the intermittent internal use of large doses of potassium or sodium iodid, 2 to 40 grams being given three times daily for two weeks, in association with Roentgen-ray treatment, with intermissions of one or two weeks.

Operative Treatment.—Sinuses and diseased tissue are excised, as far as is possible, and a 2 per cent. solution of nitrate of silver freely applied.

Ascites (*hydroperitoneum*) is the accumulation of a non-purulent fluid in the peritoneal cavity.

Etiology.—A. *Increased pressure* in the portal circulation as from: (1) Cardiac disease; (2) pulmonary disease, and (3) hepatic disease.

B. *Pressure on the portal vessels* before entering the liver from: (1) Lymphatic leukemia; (2) enlarged mesenteric glands; (3) tumors; (4) parasitic cysts; (5) inflammatory thickening, and (6) aneurysm.

C. *Disease of the Peritoneum.*—1. Tuberculosis; (2) disease of the lymph-glands. (3) Abdominal tumors: (a) Primary; (b) secondary, as papillary cystomata of the ovary, secondary peritoneal growths from cancer of the stomach, bowel, or pelvic organs.

In the order of their frequency the *common causes* are: (a) Cardiac weakness, renal disease, hepatic cirrhosis, peritoneal cancer, ovarian tumors, peritoneal tuberculosis. (b) The *uncommon causes* are intestinal obstruction, intestinal cancer with glandular metastases, uterine fibromyoma, pericardial adhesions, hepatic cancer, pernicious anemia, leukemia, mesenteric thrombosis, abdominal lymphoma, visceral syphilis, and caval and portal thrombosis.

Collateral circulation in portal obstruction is by: (1) Accessory portal system of Sappey—(a) veins in round ligament to epigastric and mammary veins (caput

medusæ); (b) veins in suspensory ligaments of liver, in diaphragm, and vena azygos to superior vena cava. (2) Esophageal and gastric veins. (3) Retroperitoneal veins between portal and caval veins of Retzius. (4) Inferior mesenteric and hemorrhoidal veins.

Varieties of Ascites.—1. *Serous Ascites:* Clear amber fluid, with a specific gravity over 1.015 in exudates, under 1.015 in transudates. It may coagulate after withdrawal.

2. *Hemorrhagic ascites* occurs from carcinoma, tuberculosis, ectopic pregnancy, pancreatitis, volvulus, and intussusception.

3. *Chylous ascites* is: (a) True (cleared by ether) from obstruction to lacteals or thoracic duct, as by cancer or filaria. (b) False (opalescence from lipoids, cleared by alcohol, but not by ether) may occur in any form of ascites, especially the nephritic, giving a bad prognosis.

Cytology.—Small lymphocytes (tuberculosis), endothelial cells (peritonitis), and cancer-cells (malignancy).

Diagnosis is made by the associated causal condition, and the: (a) Uniform abdominal enlargement; (b) shifting dulness; (c) resonance above, dulness below and in the flanks, and (d) the fluid wave.

Treatment.—A. Medical: The cause should be corrected, restricting liquids and using a salt-free diet with diuretics and cathartics. In ascites from cirrhosis of the liver large doses of calomel or the mercurial salt, novasurol, may be tried to produce free diuresis. Novasurol is given intramuscularly or intravenously, in doses up to 2 c.c., at intervals of three days to a week. The tolerance should first be determined by the administration of 0.5 to 0.75 c.c. intramuscularly. Ammonium chlorid in doses of 0.75 to 1.50 gm. is given conjointly by mouth, up to 10 gm. daily being used.

B. Surgical: 1. *Paracentesis Abdominis:* (a) Semisitting posture; (b) the bladder should be empty; (c) local anesthesia; a dull area in the midline between umbilicus and pubis, not adjacent to a previous scar, being selected; (d) a short incision is made through the skin; (e) the trocar is plunged through parietes toward the hollow of sacrum, the intestine floats away; (f) the cannula is withdrawn; (g) the fluid permitted to escape slowly, as a scultetus binder is gradually tightened to maintain the intra-abdominal pressure. After the evacuation the puncture may be sealed by collodion and cotton, and a bandage firmly applied to maintain the intra-abdominal tension. *Tubes of glass* or *rubber* may be introduced through the cannula, which is removed, and drainage permitted for several hours, or *Southey's capillary tubes* may be inserted in each flank.

2. *Handley's lymphangiorrhaphy:* Tubular silk threads are carried subcutaneously from a knotted end left in abdomen to the thigh and buttock for permanent drainage.

3. *Tubes of hardened* (formalinized) *blood-vessels* are introduced by operation, running from the peritoneum to the subcutaneous tissue of the loin.

4. *Peritoneosaphenous Anastomosis.*—The great saphenous vein is divided 15 cm. below Poupart's ligament, the proximal end turned up and anastomosed with the edges of an opening into the peritoneum. The valves in the veins prevent the reflux of blood into the abdominal cavity.

5. *Talma Operation (Epiplopexy).*—An upper right rectus incision is made,

and the great omentum sutured in a pocket in sheath of rectus. *Morrison's addition* is to scarify the liver and adjacent surface of diaphragm.

6. *Splenectomy* may cure by relieving the liver of toxic substances and reducing the bulk of blood in the portal veins by 20 per cent.

In cirrhosis, from the general condition of the patient, all abdominal operations are dangerous. Repeated paracentesis produces rapid wasting and cachexia. To retrieve liquids and proteins that otherwise would be lost the ascitic fluid may be poured back into the patient's veins at the time of the paracentesis.

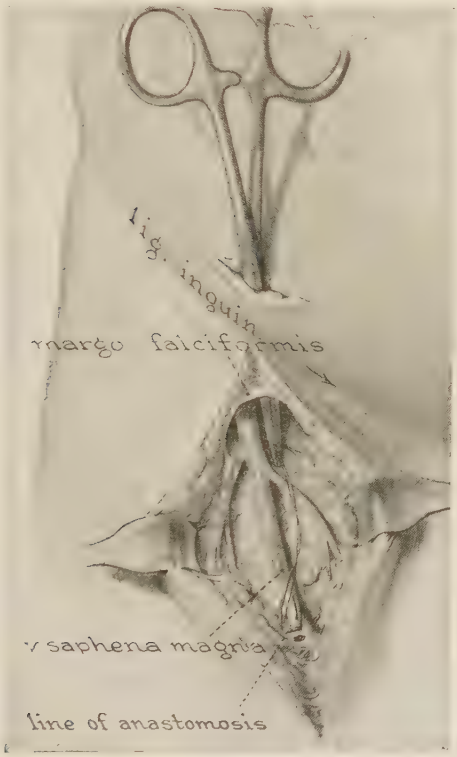


Fig. 768.—Peritoneosaphenous anastomosis for ascites. Great saphenous vein divided preparatory to withdrawal through peritoneal incision.

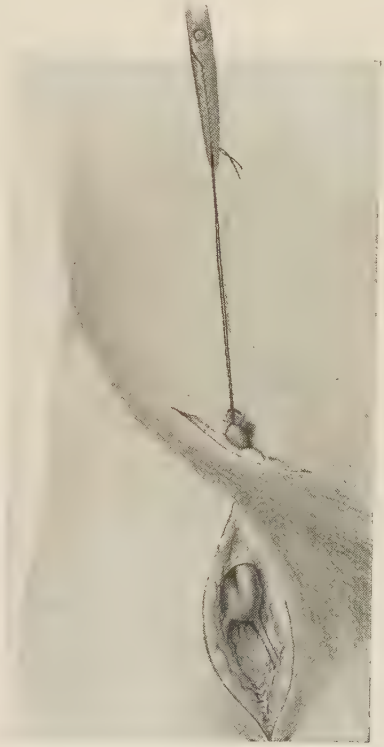


Fig. 769.—Peritoneosaphenous anastomosis. Great saphenous vein divided and withdrawn through abdominal incision preparatory to anastomosis.

While technically somewhat delicate and not always reliable, the operation of peritoneosaphenous anastomosis is theoretically superior and at times gives the patient complete relief.

Polyorrhomenitis (*polyserositis, Concato's disease*) is characterized by the exudation of serum and by endothelial proliferation in two or more serous cavities, with chronic indurative or hyperplastic thickening of the serous membrane. It affects the peritoneum, pleura, pericardium, and mediastinum.

Local forms occur with proliferative perisplenitis and perihepatitis (*sugar-ice liver, Zuckergussleber*), characterized by a deposit of white connective

tissue over the liver and spleen, the underlying and adjacent organs not being much involved, with or without free fluid in the peritoneum.

Etiology.—Middle age, male sex, alcoholism, rheumatism, and gouty conditions, or the same factors that produce arteriosclerosis. Adhesive shortening and thickening of the great omentum and mesentery are usually associated.

Treatment is the same as for chronic ascites (paracentesis, short-circuiting, possibly splenectomy). Operation is usually unsatisfactory.

Cysts of Peritoneum.—1. *Inflammatory exudation* of clear or turbid fluid limited by peritoneal adhesions often follows inflammatory process and operation, and especially involves the pelvic peritoneum. The tense, thin-walled cyst may cause local or reflex pain and, in many cases, can be ruptured by bimanual pressure after placing one or two fingers in the rectum or vagina. A transient peritoneal irritation follows the rupture. If the cysts recur, the wall should again be ruptured by pressure. Care should be taken to differentiate thick-walled inflammatory accumulations.

2. *Cysts of embryonic origin* occur in the peritoneum from remains of the vitello-intestinal duct, or the wolffian body.

3. *Retention cysts* occasionally develop in the lacteals of the mesentery (chylous cysts of the mesentery).

4. *Parasitic peritoneal cysts* are usually echinococcic, rarely cysticercic.

5. *Neoplastic cysts* occur from fetal inclusion and the growth of tumors.

Treatment is excision.

Tumors of the Peritoneum.—Varieties: (1) Extraperitoneal. (2) Intraperitoneal.

Endotheliomata are *primary* in the peritoneum, or *secondary* from the stomach, ovary, bowel, or occasionally the breast. They form large masses, with multiple nodules, without caseation. They are of a gray color, are vascular, and occur in the middle aged. The omentum is enlarged, rolled up, and occupies the upper abdomen. Ascites occurs early, being (a) clear, (b) bloody, or (c) chylous.

Diagnosis is made absolute by: (1) Paracentesis, cytologic and bacteriologic study, and (2) abdominal section. Tubercles occur in the young, are avascular, embedded in peritoneum, gray or yellow, show caseation, and are never pedunculated or villous.

The *prognosis* is unfavorable.

Treatment is unsatisfactory. Radiation or intravenous administration of colloidal metallic salts may be tried.

Sarcomata are usually retroperitoneal, encapsulated, and of rapid growth. Recurrence follows excision, and the patient may live a number of years and survive several operations.

Treatment.—Enucleation in the earlier stages gives temporary relief. Life may be prolonged by Roentgen or radium therapy

Secondary tumors of the peritoneum are usually carcinoma, the primary growth being in the stomach, uterus, colon, ovaries, mammary gland, or other adjacent organs. The peritoneum may be studded by minute papular growths and, with obstruction of the lymphatics, ascites (clear, hemorrhagic, or chylous) follows.

Prognosis and Treatment.—With the development of ascites, the patient with secondary carcinoma of the abdomen rarely lives over three months; occasionally a rather remarkable prolongation of life for from two to five years follows deep Roentgen therapy. The abdomen is divided into twenty or thirty areas for "cross-firing." Forty milliampere-minutes with a focal distance of 8 inches and a 9-inch parallel spark-gap, the rays being filtered through 6 mm. of aluminum or glass, are used by Pfahler.

CHAPTER XLIX

THE STOMACH AND DUODENUM

Symptomatology.—Dyspepsia is characterized by:

1. *Coated Tongue:* (a) Large flabby tongue marked with thick, white or yellowish fur; (b) red, beefy, moist; (c) glazed, dry, coated, brown; associated with sordes on teeth, dehydration, and advanced toxemia.

2. *Perverted Appetite:* (a) Anorexia; (b) unnatural craving of food; (c) craving for unusual or abnormal foods (*pica*).

3. *Fulness* or *distress after eating* occurs immediately, shortly, or after two to four hours; with sense of pressure, weight, gnawing, and burning (*cardialgia, heart-burn*), eructations and belching of gas, frequently sour or bitter; *water-brash*, the bringing up of clear watery fluid; *pyrosis*, of a burning acid fluid.

4. *Palpitation* of the heart, due to pressure of the distended stomach or to absorbed toxic material.

5. *Headache.*

6. *Constipation* (usually).

7. *Nausea* and *vomiting* at times.

Qualitative dyspepsia, an idiosyncrasy to special foods: As sour, greasy, or salty foods; pastries, strawberries, milk, tomatoes, eggs, or the like; often with cardialgia. Qualitative dyspepsia is usual in biliary disease.

Quantitative Dyspepsia.—The quantity rather than the quality or character of food affects the patient's comfort, as in ulcer of the duodenum and hyperchlorhydria.

Dyspepsia of Hyperchlorhydria.—The appetite is good, but fear of distress may prevent eating. There is temporary comfort after taking food (*food-ease*), and distress when the stomach is empty (*hunger-pain*).

Vomiting, characterized by: (1) Salivation, creepy or shivering sensation; (2) one or more deep inspirations, with fixation of the diaphragm; (3) spasmodic closure of the pylorus; (4) spasmodic contractions of the abdominal muscles, with the expulsion of food.

Causes of the Vomiting.—(1) Chronic toxemia, as in nephritis, cirrhosis of the liver; (2) reflex causes, as stone in the kidney, testicular injury, salpingitis; (3) brain tumor or intracranial pressure; (4) obstruction of the alimentary tract or ileus; (5) drugs; (6) early pulmonary tuberculosis; (7) neurosis.

Time of Vomiting.—In relation to taking food: (a) Immediate, as in obstruction of cardia or esophagus; (b) morning vomiting occurs in cirrhosis of the liver, pregnancy, nephritis, and alcoholism; in the latter being associated with much mucus. It is delayed in chronic pyloric obstruction, with the expulsion of large amounts of food eaten twenty-four or thirty-six hours previously, which separates into three layers: The upper, clear or frothy; the middle, turbid; the lower, partially digested food particles.

In intestinal occlusion, the lower the obstruction, the more delayed the vomiting after taking food.

Inspection of the Stomach.—*Gastroscopy:* A limited inspection of the interior of the stomach is possible with the open air-inflating gastroscope of Jackson, or the lens-system instrument of Janeway.

In children and infants pyloroscopy is possible, a thread first being swallowed, which is followed by observation through the gastroscope to the pylorus, the pylorus being pushed to the left by the examining hand.

By peroral pyloroscopy Jackson successfully removed a safety-pin from the pylorus in an infant. It is of advantage to combine the examination with that of a double-plane fluoroscope.

Gastrostomy-pyloroscopy is used for diagnosis and treatment of duodenal and pyloric conditions. The gastrostomy is first made close to the midline on a level with the pylorus, a string guide introduced, and observation and topical applications to the stomach and pylorus made through a gastroscope passed through the fistulous opening.

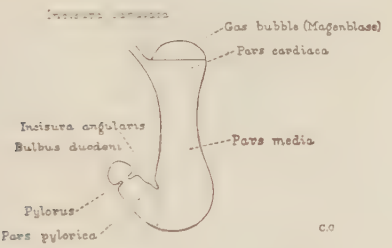


Fig. 770.—Fish-hook stomach. The usual vertical type, indicaing the parts shown by the roentgenogram (Carman).

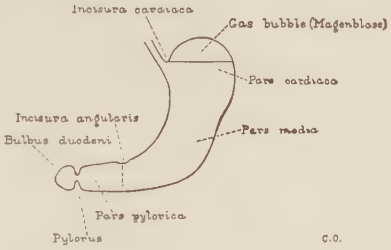


Fig. 771.—Steer-horn stomach. A transverse type of stomach infrequently shown by roentgenogram (Carman).

Congenital Anomalies.—Stenosis of the pylorus is the most common anomaly of the stomach, and results from hypertrophy of the circular muscle. A true contraction or occlusion of the pyloric orifice is unusual. Rarely (1) a stenosis of the second portion of the duodenum, (2) an hour-glass stomach, (3) a transverse partition across the stomach or, very rarely, (4) a stenosis of the body of the stomach is present.

Congenital Hypertrophic Stenosis of the Pylorus.—*Pathology:* A hypertrophy, chiefly of circular layer, of the muscular wall of lower part of the antrum and pylorus of the stomach to four or five times the normal thickness. The mucous lining is not adherent to the overlying muscularis, is thrown in folds, and is not contracted; the remainder of the stomach may undergo hypertrophy or dilatation.

Etiology.—Male babies and the first-born are especially affected, and the condition is due more to muscular hypertrophy and spasm than a true stenosis. Hyperchlorhydria is not constant. A deficiency in bile or pancreatic juice may be responsible for the failure of the pylorus to relax.

Symptoms.—Sudden forcible vomiting, beginning two to four weeks after birth, of progressive projectile type, but with variable intervals; associated with constipation, scanty concentrated urine, colicky pains, gastric retention, dehydra-

tion, marked wasting, scaphoid abdomen, visible recurrent gastric peristalsis from left to right, and a palpable olive-shaped mass at the pylorus.

Prognosis.—If not relieved, the child progressively emaciates, weakens, with subnormal temperature, possibly edema, convulsions, and finally dies. The mortality under diet and medical treatment is 30 to 60 per cent., dependent on the degree of spasmodic element. The operative mortality of 5 per cent. is tripled if the condition has lasted over four weeks, if artificial feeding has been used, if baby has lost over 20 per cent. of its best weight, or weighs less than 7 pounds.

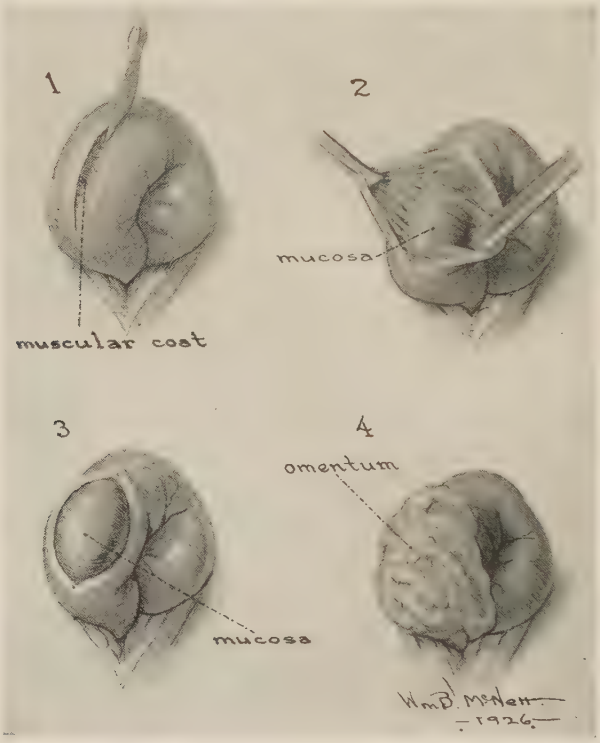


Fig. 772.—Rammstedt's method of pyloroplasty: 1, Incision through submucosa avoiding the duodenum; 2, separation of submucosa; 3, enlargement of pyloric ring; 4, omentum applied to the muscular defect.

Treatment.—1. Medical: Mild and spasmodic forms respond to lavage, atropin, and careful feeding (including small frequent feedings), the food being alkalinized by the addition of 2 or 3 grains of sodium citrate or bicarbonate. Thick farina feeding has at times been very effective. An alkaline lavage is given twice daily, also colonic irrigation with saline solution.

2. Operative: Indicated if child does not improve or gain weight in ten days of careful medical treatment; and should not be delayed until extreme inanition develops.

Pylorotomy (Rammstedt's operation): (1) Preliminary lavage with 1 per cent. sodium bicarbonate solution; (2) child bandaged to padded board, and protected from cold; (3) local anesthesia by $\frac{1}{2}$

per cent. procain-adrenalin; (4) 5 cm. vertical upper right rectus incision, splitting the outer third of the muscle; (5) pylorus is gently hooked through wound by a blunt hook, and held by thumb and finger; (6) superficial longitudinal incision at junction of upper and middle thirds of anterior surface of pylorus, from duodenal margin well into prepyloric portion of stomach, with blunt separation of muscles by fine hemostat until mucosa freely bulges through wound; (7) oozing controlled, if necessary, by hot sponges; bleeding points, by ligation. Care should be taken not to carry the incision below the pyloric ring, as the duodenum is thin and easily penetrated. If the mucous membrane has been perforated it should be closed by 00 or 000 chromic catgut or fine silk and reinforced by sewing some of the great omentum over the weak point. (8) The abdominal wound is securely closed in layers without drainage after filling the peritoneal cavity with warm saline solution (Strauss). (9) Fifteen c.c. of warm water are given one-half hour after operation, and thereafter every three hours, between feedings. Feeding is begun three hours after operation with 15 c.c. of breast milk or a dilute powdered milk, barley-water, and sugar formula. The food is given every three hours, and gradually increased and modified to meet individual requirements. Breast feeding may be resumed after one week, but each feeding should not exceed 60 c.c. until two weeks have elapsed.

Extreme dehydration and inanition should be combated with saline solution subcutaneously, and glucose and saline intravenously.

Pylorotomy is very effective, and may be done in five or ten minutes. Great care should be taken in feeding the infant after the operation.

Injuries of the Stomach.—1. **Injuries from External Violence Without Open Wound.**—In order of frequency, the abdominal portions of the alimentary canal suffer from subcutaneous injuries as follows: (a) Ileum, (b) jejunum, (c) colon, (d) stomach, (e) duodenum.

The stomach may be contused, torn from its attachments, or ruptured by force applied through the abdominal wall, from kicks, blows, crushes, run-over accidents, or Momberg's tourniquet. The stomach of an aged person, a diseased stomach, or one distended by gas, liquid, or food is more susceptible to rupture. Usually the force is applied directly over the stomach, occasionally it is transmitted as from a blow over the lower abdomen or, rarely, by a fall upon the feet. Even violent contraction of the abdominal muscles has produced rupture of the normal stomach.

Symptoms.—Marked shock, intense pain in the abdomen with, if the stomach has been ruptured, evidence of free liquid (gastric contents, blood, gas) in the abdominal cavity, and board-like involuntary rigidity of the abdominal muscles. Vomiting may not occur unless liquid is taken by mouth. The respirations are thoracic, later the abdomen becomes distended with the symptoms of increasing peritonitis.

Treatment.—In any case of abdominal injury, with either involuntary board-like contraction of the abdominal muscles or evidence of free gas or free fluid in the abdominal cavity, the abdomen should immediately be opened. In no case should one wait to see if a peritonitis develops. With peritonitis existing the operation should also promptly be done. In rupture of the stomach the danger rapidly increases with delay, yet occasionally patients are saved by operation several days after the receipt of the injury.

2. **Perforating wounds of the stomach** occur from gunshot injuries, stab wounds, and punctures from falls upon sharp or jagged objects. Occasionally a missile will enter and remain in the cavity of the stomach. After perforations by small-bore rifle bullets the thick gastric mucosa may prolapse into the opening and prevent leakage. While this spontaneous closure may be successful, it

should not be depended upon. The treatment of penetrating or perforating wounds of the stomach from without is immediate operation with closure or occlusion of all openings.

3. **Injuries of the Stomach from Within.**—The stomach may be perforated from within by the use of bougies or stomach-tubes; by exhibitionists in sword-swallowing, from swallowed glass, knives, forks, pins, or other sharp objects. These objects perforate the stomach, lacerate the mucous membrane, or, rarely, open an important blood-vessel or varicose vein with a secondary serious or even fatal hemorrhage. Perforation by gall-stones or by round-worms occurs rarely.

Burns of the Stomach: Follow the ingestion of caustic acids or alkalies, such as carbolic, hydrochloric, nitric, or sulphuric acid; caustic soda or potash, ammonia, oxalic acid, or such corrosive poisons as mercuric bichlorid or zinc chlorid. Almost invariably there is an associated burn of the mouth and esophagus. The irritation of the caustic causes the stomach to contract and the pylorus

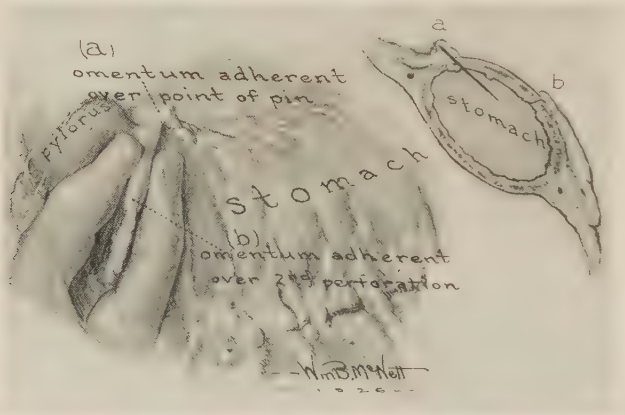


Fig. 773.—Two perforations (*a*, *b*) of the stomach near the pylorus, due to a pin, occluded by adherent omentum. The patient did not recall having swallowed the pin, and the symptoms were those of a chronic perforated ulcer.

to close, the caustic being held chiefly against the mucosa of the lesser curvature and pyloric end, which bears the brunt of the erosion. There is intense pain, thirst, and vomiting of blood and shreds of mucous membrane. Perforation of the stomach may occur, or necrosis and sloughing of the mucous membrane, with secondary phlegmon, ulceration, cicatricial contraction, or stenosis.

Treatment.—Emesis should be encouraged, and the caustic diluted and neutralized. For carbolic acid, magnesium sulphate and whisky or other dilute solution of alcohol are given; for mineral acids, magnesia, chalk, or milk. Baking soda or other bicarbonates may produce dangerous tension by the liberation of carbonic-acid gas. For caustic alkalies, vinegar or lemon juice should be administered; for arsenic, the hydrated sesquioxid of iron. Demulcents, such as raw eggs and mucilaginous gruels from flaxseed or acacia, should be freely used. Lavage should be avoided for fear of perforating the stomach, unless some intense poison, such as arsenic or corrosive sublimate, has been taken.

Early operation may be required: (1) In perforation, to suture or to isolate the leaking area by gauze packing; (2) in severe corrosion, a jejunostomy is desirable to place the stomach at rest, facilitate healing, and maintain nutrition. Feeding by mouth is interdicted until healing has occurred.

Strictures and stenoses following burns of the stomach require a secondary gastro-enterostomy, pylorectomy, partial gastrectomy, or a permanent gastrostomy or jejunostomy. If the occlusion is at the cardia, a gastrostomy or jejunostomy may be necessary for feeding, to be followed (after healing has taken place) by dilatation of the cardia as described under strictures of the esophagus.

Foreign Bodies in the Stomach Enter: (1) Through the mouth and esophagus (swallowed); (2) from an adjacent viscus (gall-bladder, peritoneal cavity, colon, duodenum); (3) abdominal wall (bullets, shrapnel).

Usually the object is swallowed by accident or design. The patients are: (1) Children; (2) the insane; (3) exhibitionists who swallow glass, knives, forks, portions of chain, masses of metal, and other objects; (4) the neurotic or hysteric (hair-balls); (5) persons who accidentally swallow teeth, loose dentures, needles, pins, fish or meat bones, cherry pits and peach kernels, and other objects.

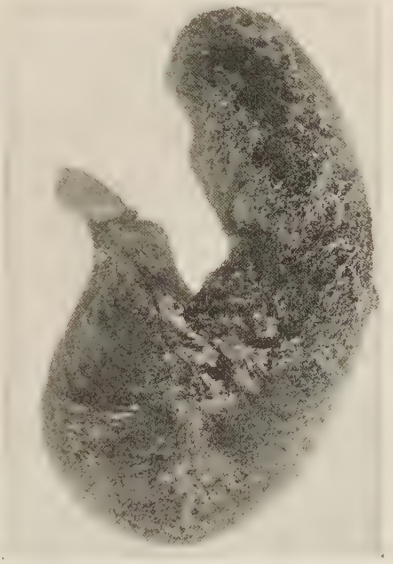


Fig. 774.—Hair-ball or trichobezoar weighing 2 pounds and almost filling the stomach. Removed from a girl of ten years (Carman, Mayo Clinic).

Bezoars.—A. Trichobezoar (Hair-ball): Nervous and hysteric young women may bite off and swallow ends from their hair, giving rise to a hair-ball. The hair-ball may weigh several pounds, form a complete cast of the stomach, and be felt through the abdominal wall as a large firm tumor.

B. Phytobezoar (Food-ball): Is a similar object formed of vegetable products, such as the hairy husk of the cocoanut, or skins, seeds, and fibers of various fruits and vegetables. Shellac swallowed for the stimulating effect of the alcohol solvent may form concretions in the stomach (shellac-stones). A foreign body may enter the stomach from an adjacent structure (as round-worms from the duodenum, gall-stones from the duodenum) or by direct ulceration through the walls of the stomach. A Murphy button, placed by the surgeon in gastro-enterostomy, may be dislodged into the stomach instead of passing into the intestine. Gauze and surgical instruments left in the abdominal cavity at times penetrate into the stomach, and needles may work their way from the abdominal or gastric wall into the stomach.

Symptoms.—A foreign body may: (1) Pass without producing symptoms, especially if less than 3 cm. in diameter; (2) be retained in the stomach without symptoms, or (3) cause gastritis, ulceration, abscess, perforation, peritonitis, or fistula formation.

Exhibitionists and the insane may continue to swallow foreign bodies for one or two years without symptoms, and with the passage of many of the swallowed objects. Ultimately, as the weight drags down the greater curvature, the foreign bodies no longer escape through the pylorus, and serious digestive symptoms from gastritis and ulceration develop.

Diagnosis is made by the history, physical examination, the roentgenogram, the esophagoscope, or the gastroscope. With a bezoar or gall-stone, the barium meal surrounds the foreign object which of itself does not cause a shadow upon the film. Swallowed needles may migrate to various portions of the body without causing serious symptoms.

Prognosis.—Obstruction, ulceration, perforation, and peritonitis are to be feared.

Treatment.—If sharp or jagged objects have been swallowed, laxatives should be avoided and constipation encouraged, the patient being given the *Vienna treatment* of large quantities of bulky food (potatoes, bread, peas, beans, cabbage). Even better is absorbent cotton, which is shredded through milk or ice-cream and freely swallowed. Peristaltic movements wrap the cotton fibers about the foreign object.

Gastrostomy, or *gastroscopy* and *operative removal*, is indicated if the foreign body: (1) Causes obstruction, ulceration, perforation, or serious symptoms; (2) is retained as a menace to health.

Phlegmonous gastritis (*phlegmonous gastroduodenitis, suppurative gastritis, gastric abscess*) is rare, occurring as a (1) *circumscribed* or (2) *diffuse* process, with a wide-spread suppurative infection of the submucosa, usually streptococcic.

Etiology.—The infection occurs chiefly in men, in middle life, in alcoholics, and during severe exanthematous diseases, as typhus, typhoid, smallpox, puerperal fever, and pyemia.

Symptoms are those of a violent sepsis, with early and repeated vomiting, marked upper abdominal tenderness, rigidity, mass, high temperature, rapid pulse, leukocytosis, and severe constitutional disturbance. The diffuse form may be fatal within a few days. The localized type results in an abscess in the wall of the stomach. Peritonitis and diffuse sepsis is common.

Diagnosis is to be made from acute pancreatitis, perforating gastric ulcer, abscess of the liver, and peritonitis.

Prognosis is unfavorable, although recovery has followed the evacuation of localized abscesses.

Treatment consists in abstention from liquid or food by mouth, early abdominal incision, the evacuation of abscesses, the walling off of the affected portion of the stomach by gauze, and a jejunostomy for feeding.

Gastric Fistula.—**Varieties:** (a) Internal, one in which the stomach communicates with another hollow viscus; (b) external, one in which there is an opening upon the skin.

Internal fistulæ frequently communicate with the colon, rarely the duodenum, occasionally with the pleura, bronchi, pericardium, gall-bladder, kidney, or uterus. Often a communication to the colon is due to the marginal ulcer following gastro-enterostomy. *External fistulæ* usually open upon the anterior abdominal wall.

Etiology.—(1) Gunshot and other wounds involving the stomach; (2) foreign bodies that have ulcerated out of or into the stomach; (3) operation, ulcer, or carcinoma involving the stomach or some adjacent viscus.

Acute gastric fistula, *acute duodenal fistula*, and *high intestinal stasis* may produce marked increase in carbon-dioxid combining power of the blood-plasma; increase of the urea content of the blood, and a decrease in the chlorid content. The increase of carbon-dioxid combining power is much greater with the gastric fistula, indicating that the alkalosis from gastric fistula is due to loss of acid from the stomach. Sodium chlorid solution is valuable in the treatment.

Duodenal fistula follows a right nephrectomy, with injury to the extraperitoneal portion of duodenum in separating or ligating the renal pedicle. There is escape of bile, pancreatic juice, and chyme from the lumbar opening, with erosion of adjacent skin.

The duodenal fistula is persistent, difficult to close, and the condition is not improved by gastro-enterostomy. Access is difficult through either the loin or abdomen, the duodenum often reopens after suture, and the mortality is high. The anterior approach is to be preferred, the duodenum being liberated, turned to the left, sutured, and the suture line covered by a layer of omentum.

Diagnosis.—*External Fistula:* Swallowed liquids and foods appear at the external opening. For test purposes, carmine or methylene-blue may be added to the food, and Roentgen study made after injecting bismuth paste into the fistula and also after a barium meal and enema.

Diagnosis of *internal fistula* may be more difficult. If the stomach communicates with the colon, lientery or diarrhea with the prompt passage of undigested food may occur. Eructations of fetid gas from the colon and true fecal vomiting may be present. Careful Roentgen studies after the administration of barium meals and enemas are diagnostic if correctly interpreted.

PEPTIC ULCER

Varieties.—A. *As to Site*—(1) Gastric; (2) duodenal; (3) marginal or gastrojejunal.

B. *As to Duration*—(1) Acute; (2) subacute; (3) chronic.

C. *As to Pathology*—(1) *Ulcus simplex;* (2) *ulcus penetrans*, perforating ulcer; (3) *ulcus callosum*, indurated ulcer.

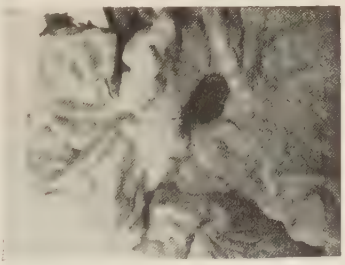


Fig. 775.—Ulcer of the stomach (Carman).

Etiology.—(1) Traumatic (foreign bodies); (2) chemical, from peptic erosion or corrosive poisons; (3) specific—syphilitic, tuberculous, actinomycotic, from anthrax, typhoid fever; (4) toxic, as Curling's ulcer in extensive burns; (5) embolic; (6) malignant, as in carcinoma; (7) focal infection, especially by streptococci.

Duodenal ulcer is the most common (80 per cent.). Marginal ulcer follows 4 to 6 per cent. of gastro-enterostomies. Chronic, callous and perforating, and duodenal ulcers are more common in men. Gastric erosion usually occurs in

young women. Ulcer of the third portion of the duodenum is rare. The jejunum is rarely involved except after gastro-enterostomy.

The favoring causes of ulcer are: Poor dentition, focal infections of the mouth, nasopharynx, or portal area, including the appendix and gall-bladder; gastric hyperacidity which may result from pyloric stenosis, pylorospasm, or as a nervous reflex.

Acute Gastric Ulcer or Erosion.—These ulcers involve by preference the posterior wall and fundus, are small (2 to 3 mm. in diameter), oval, rounded, with a sharp punched-out edge, and a smooth floor formed by the submucosa, muscular wall, or peritoneum; the edges are not indurated, but are injected and edematous. The blood-vessels of the submucosa are often eroded, with severe hemorrhage. Perforation occasionally occurs. These ulcers heal without cicatricial contraction.

Etiology.—Acute ulcers occur in young women with anemia or chlorosis and, occasionally, in men. Often they are associated with appendicitis, septicemia, or septic intoxication.

Symptoms.—Epigastric pain after eating, with deep and superficial tenderness over the epigastrium, vomiting, often with incomplete relief. Hematemesis is common, often profuse, but rarely fatal.

Treatment.—Dietetic, hygienic, and medicinal. Operation is not required.

Chronic Gastric Ulcer.—*Site:* Ninety per cent. of chronic ulcers occur along the lesser curvature of the stomach or original gastric canal (*Magenstrasse*), or in the area supplied by the right gastric artery (Balfour). The second situation is the prepyloric ring and antrum.

Ulcers occur chiefly in the pyloric end of the stomach, on the lesser curvature and posterior wall. They may extend down both posterior and anterior walls, forming a *saddle-ulcer*, or a posterior ulcer may coexist with a corresponding anterior ulcer (so-called *kissing ulcers*). Eighty per cent. of the chronic ulcers are single. Ulcers within 2 cm. of the duodenum usually are duodenal.

Pathology.—Chronic gastric ulcer (*ulcus callosum*) is round or oval, the edges rounded, indurated, and sharply punched out. The ulcer is deep, the base being (1) in the depths of the muscularis, (2) at the peritoneal coat, or (3) formed by adherent pancreas or liver. The overlying peritoneal coat frequently shows puckered, radiating, yellowish or grayish fibrous deposit. By adjacent swelling due to infiltration and edema the ulcer may produce pyloric obstruction; and in healing cause cicatricial contraction, stenosis, hour-glass contraction, or other deformity of the stomach.

Etiology.—More frequent in men than in women, chronic ulcer usually occurs between the ages of thirty and fifty. The precise etiologic factor is unproved. The ulceration has been ascribed to: 1. Anemia and blood dyscrasia.

2. Hyperacidity with autodigestion (corrosion theory).

3. Thrombosis and embolism associated with arteriosclerosis or other vascular change (circulatory theory).

4. Focal infection, with selective affinity of bacteria for the stomach (Rosenow).

5. Traumatism: (a) Chemical; (b) thermal; (c) physical.

6. Neurogenic defect involving the vagus or sympathetic, with hyperse-

cretion, hypermotility, and trophic changes. A neuritis or perineuritis may be found in fibers adjacent to the ulcer (neurogenic theory).

Symptoms.—Distress, with sense of fulness or lump in the epigastrium or lower thorax, that may radiate over the epigastrium or between the shoulder-blades. Pain occurs in from one-quarter to two and one-half hours after meals, the pain being relieved when food is taken (food-ease); and also by bismuth, alkalies, and vomiting. The rhythm of symptoms is: (1) Food; (2) comfort; (3) pain; (4) comfort, repeated with each meal (Moynihan). The closer the ulcer is to the cardia, the earlier the pain after eating. Vomiting occurs in about one-half of the cases, usually at the height of the pain, with immediate relief. Hematemesis occurs in 25 per cent. of the cases. Occult blood is usually found in stools and gastric washings. The appetite is good, but the patient often refrains from eating for fear of the secondary pain and, as a result, becomes lean and thin faced. Deep epigastric tenderness and frequently some spasm of the upper rectus is common. The attacks have periodicity, being more frequent in the colder months, last two to six weeks, and temporarily disappear with or without treatment.

Fig. 776.—Incisura at *b*, opposite gastric ulcer at *a* (Carman).

Diagnosis.—There is increase of free HCl and the total acidity; the fractional meals usually show prolonged digestion, with increased acidity, but less marked than in duodenal ulcer. Hypo-acidity is found in 2 per cent. of the patients.

Roentgenography.—1. *Positive Findings:* (a) A barium- or bismuth-filled *crater;* (b) *incisura* in the gastric outline, projecting from the greater curvature and pointing toward the barium-filled crater, which resists belladonna, and is due to peristaltic spasm; (c) *accessory pocket*, an outlying barium- and gas-filled loculus, which is found in a chronic perforated ulcer only; (d) *organic hour-glass* in which the stomach forms two loculi that persist despite manipulation or the use of belladonna.

2. *Suggestive Findings:* (a) Suspicious area, coinciding with a tender point on pressure. (b) Evidence of perigastric adhesions. (c) Persistent deformity of the duodenal cap. (d) Motor irritability, hyperperistalsis, spasticity.

Differential Diagnosis: See Duodenal Ulcer and Perforated Gastric Ulcer.

Prognosis.—Acute ulcers and erosions are usually curable by medical treatment; chronic, callous ulcers are relieved by diet, sedatives, and alkalies, are subject to long periods of relief, but tend to recur and persist, so that eventually operation is resorted to.

Treatment.—Symptoms, including those of pyloric obstruction, are relieved in a large percentage of cases by Lenhartz's diet or the Sippy treatment. The latter consists in a graduated diet, rest in bed, neutralization of the gastric acidity by a soluble (sodium bicarbonate) and insoluble (magnesium carbonate) alkali, associated with bismuth subnitrate or carbonate. Complete relief followed after months by recurrence of symptoms is very common after medical treatment.

Routine Treatment in Suspected Peptic Ulcer (Lahey and Jordan).—1. A careful **history,** noting duration, remissions, and relation to food. Distress in uncomplicated ulcer is constant in time and in relation to food. There is constant finger-point location, and possible radiation to the back, with gradual onset and subsidence and relief by adequate food, alkalies, or vomiting.

2. By **examination** exclude pulmonary tuberculosis, cardiac, renal, blood disease, or reflex gastric symptoms from pelvic or intra-abdominal lesions and tabes.

3. **Preparatory Treatment.**—*On admission,* rest in bed, modified soft diet without meat or meat extractives (soup or broth). A 5-gm. capsule of carmin is given, followed, after the carmin begins to be passed in the stools, by a daily test for occult blood in feces.

Second Day: (a) An early morning Ewald test-meal is given, and raised in one hour, noting quantity, food content, free HCl, total acidity, and occult blood. (b) One hour after the test-meal give motor meal containing raisins; raise in seven hours, noting quantity and degree of digestion.

Third Day: Roentgen examination including fluoroscopy, noting motility, filling defects, accessory pockets, incisura, and the duodenal cap.

4. **Ulcer diet,** modified from Lenhartz and Sippy, to be started immediately upon completion of Roentgen and other tests, and also in twenty-four hours after an operation on stomach if there is no nausea. If patient vomits—give sodium chlorid, calcium carbonate, sodium bicarbonate, of each 1 gm. in 150 c.c. of hot water immediately and as required, withholding food until eight hours have elapsed from the time of nausea.

a. *Diet for First Twenty-four Hours:* Powdered milk, 1 level spoonful (4 gm.); white of egg, 1 level spoonful (4 gm.); water 15 c.c., iced (ice not in the glass), and given every hour the patient is not sleeping or distressed.

b. *Second Twenty-four Hours* (*Third Day after Operation*): Increase the water content from 15 to 30 c.c. at each feeding; each hour between feedings give (in powder or capsule, with 15 to 30 c.c. of water) bismuth subcarbonatis, calcium carbonatis, sodium bicarbonatis, of each 0.3 gm.; magnesii oxidi, 0.1 gm.

c. *Third to Fourth Day* (*Fourth to Fifth Day after Operation*): Hourly feeding, except when nauseated or having abdominal distress. Whole raw egg, 2 drams (8 gm.); powdered milk, 1½ drams (6 gm.); water, 2 ounces (60 c.c.) at each feeding. Alkaline powder to be continued hourly, water following powder to be increased to 60 c.c. or 2 ounces.

A 4-pint soapsuds or a 1-pint asafetida enema to be given, if required, for distention.

d. *Fifth to Sixth Day* (*Sixth to Seventh Day after Operation*): Whole raw egg, ½ ounce (15 c.c.); powdered milk, 2 drams (8 gm.); water, 3 ounces (90 c.c.) at each feeding. Continue powders, increasing or decreasing magnesia to produce one soft but not liquid stool daily.

e. *Sixth Day:* Aspirate part of gastric contents at 4.30 P. M., and note degree of neutralization, modifying alkali accordingly. (Avoid during first three weeks after operation.)

f. *On the eighth day* aspirate at 9.30 P. M., on the *tenth day* at 4.30 P. M., as a guide to neutralization. If free HCl is present, 5 extra powders each time until neutralization is complete. If gastric secretion is alkaline, omit alkali from powders.

Operation is indicated by: (1) Symptoms marked, and not permanently relieved by careful medical treatment; (2) pyloric stenosis, dilatation of the stomach, hour-glass contraction of the stomach, perigastric adhesions producing symptoms; (3) acute, subacute, or chronic perforation of the ulcer; (4) evidence of malignant change.

Operative Treatment.—(1) Gastrojejunostomy, the posterior short-loop op-

eration, relieves the symptoms in about 70 per cent. of the cases. (2) Gastrojejunostomy with cauterization and enfolding of the ulcer (*Balfour's operation*) gives relief in about 80 per cent. (3) Partial gastrectomy (removal of the ulcer-bearing area, *Rodman's operation*) is the preferred operation for ulcers of the lesser curvature and pyloric end of the stomach. (4) Gastrojejunostomy, Roux's *operation en Y* combined with a jejunostomy, is advocated for very large ulcers adherent to the posterior abdominal wall, for which other treatment is not possible (Moynihan).

Complications of Chronic Ulcer.—Perforation (*ulcus penetrans*) which may be: (1) Acute with diffuse peritonitis; (2) subacute with recurrent attacks of localized peritonitis; or (3) chronic with a walled-off loculus and local peritonitis.

1. *Acute perforation* occurs in 15 to 20 per cent. of the chronic ulcers, usually between the ages of twenty and thirty-five, involving the anterior wall near the pylorus in two-thirds of the cases. Acute ulcers that perforate are more often near the cardiac than the pyloric end.

The opening usually is but a few millimeters in diameter, and preceding symptoms of ulcer are absent in over 20 per cent. of the cases. The acute and subacute perforations usually involve the anterior wall; the chronic, the posterior wall.

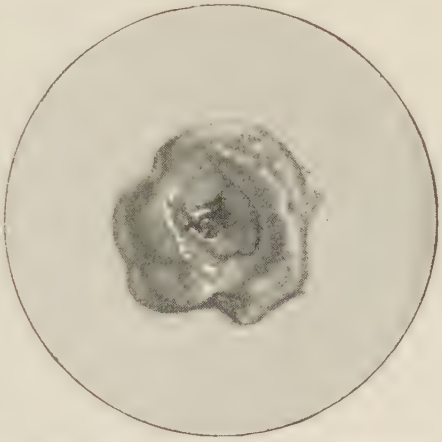


Fig. 777.—Excised gastric ulcer showing acute perforation.

An opening into the free peritoneal cavity occurs through the floor of the ulcer, with leakage of gastric or duodenal contents into the free abdominal cavity, and the rapid development of generalized peritonitis. From perforations near the pylorus, the escaped fluid gravitates into the right renal fossa, and passes over the brim of the right pelvis with predominant irritation in the lower right quadrant of the abdomen. With perforation from the posterior surface of the stomach, the fluid enters the lesser peritoneal cavity.

The fluid is mucilaginous from the presence of mucus, rarely hemorrhagic, but may be bile-stained if the ulcer is duodenal. In one-fifth of the cases perforation of more than one ulcer occurs.

Symptoms.—Acute perforation may follow a large meal, a jolt, jar, or injury with or without preceding symptoms of ulcer. There is (a) violent, acute abdominal pain that may cause patient to fall to the floor or be unable to move; (b) shock with pallid face, sweating brow, staring eyes, and appearance of agony and fear; (c) board-like rigidity of the abdominal wall, with fixation of the entire body to avoid pain; (d) the respirations are shallow, jerky, costal; (e) the temperature normal or slightly subnormal; (f) the pulse is slow, full, and of normal pressure until peritonitis develops. Pain may be referred to epigastrium, right abdomen, scapular region, or back. The rigidity is often most marked over the

area of ulcer and at McBurney's point. Vomiting often is absent until liquid or food is taken.

Examination gives the signs of free fluid and gas in the abdomen, with obliteration of liver dulness, shifting dulness in the flanks, evidence of early peritonitis in the epigastrium and right iliac fossa. Four to twelve hours from the onset, especially if an opiate has been given, a lull may occur in the symptoms, which is followed by the evidence of generalized peritonitis. Vomiting of blood or entrance of much blood into the peritoneal cavity is unusual.

2. *Subacute perforation* is characterized by slow leakage and the walling off of the area by adhesions, with local peritonitis or peritoneal abscess. Repeated

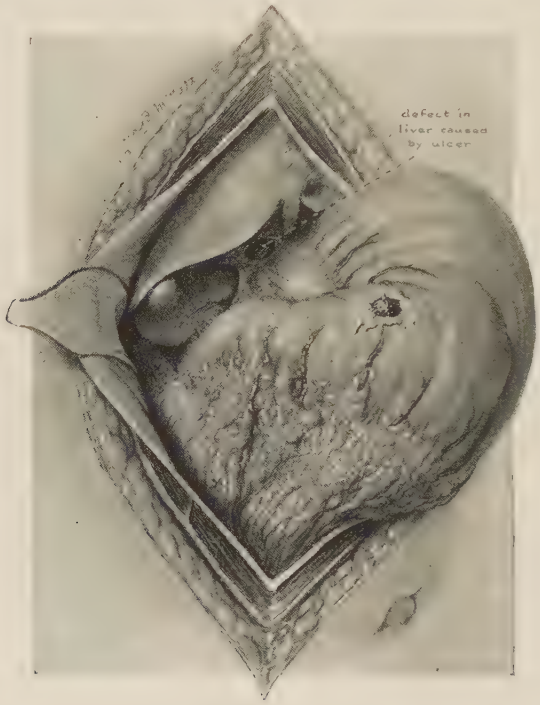


Fig. 778.—Chronic perforation of a gastric ulcer walled off by dense adhesions of the liver. Man aged fifty-two. Almost continuous pain, but not sufficient to prevent work had been present for over four months.

slight leakages may give rise to recurrent exacerbations. The pain and tenderness are less intense and more localized; a mass with overlying localized rigidity may be detected. The patient is unable to be about, but, after resting in bed with a very restricted diet for ten days or two weeks, a marked improvement usually occurs, and the patient attempts to go about or use a less restricted diet, often with re-exacerbation of the symptoms. Again the symptoms gradually merge into those of chronic perforation.

3. *Chronic Perforation.*—The area of the ulcer becomes adherent to the liver, pancreas, gall-bladder, colon, or other organ before perforation occurs, with limiting local adhesions and without marked local or general peritonitis. The patient is able to be about or to work, but has almost constant pain from which

it is difficult to obtain relief. A localized area of tenderness with overlying muscular resistance may be found in palpation over the stomach, and an *accessory pocket* shown by the roentgenogram.

Diagnosis of Perforation.—Peptic ulcers give discomfort, but not pain. Severe pain with an ulcer indicates a complication. Acute pain, of such violence as to cause shock and require an opiate, usually indicates acute perforation. Severe pain, preventing work, but not requiring an opiate, usually indicates a subacute perforation. Continued chronic pain, not absolutely preventing work, suggests a chronic perforation. Sudden and very violent epigastric pain, causing apparent shock, board-like rigidity of the muscles of the anterior abdominal wall, tenderness, dulness in the flanks and pelvis, or evidence of pneumoperitoneum in a man giving a previous history of gastric ulcer is diagnostic. Acute appendicitis is to be differentiated from a rupture of a duodenal ulcer by the more violent symptoms and shock from the perforation, with evidence of a rapid outpouring of fluid and possibly gas into the abdominal cavity, together with the preceding history of ulcer. On opening the abdomen the free abdominal fluid is found to be mucilaginous and not serous, and the adjacent intestinal coils are inflamed as well as the peritoneal covering of the appendix. A gall-stone attack is less severe, is transient, often relieved by vomiting, and the signs of peritoneal exudate and inflammation are absent.

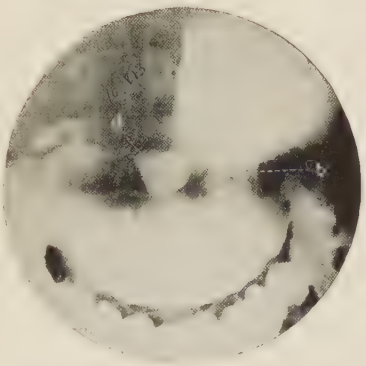


Fig. 779.—Chronic perforated gastric ulcer with accessory pocket at *a* and hour-glass contracture at *b* (Carman).

Acute hemorrhagic pancreatitis resembles perforation in its intensity, usually occurs in fleshy women over forty with a previous history of gall-stone attacks. Perforating ulcer is more frequent in men between the ages of twenty-five and forty, the preceding history pointing to ulcer. In pancreatitis there also is shock, but less free fluid and no free gas in the cavity, and epigastric fulness or a mass is present, especially to the left of the median line. On opening the abdomen the beef-broth fluid and fat necrosis are absent in perforated ulcer. In chronic perforation, gastric carcinoma may be suspected. The pain of the ulcer is more abrupt in onset, more severe, more often occurs in a younger person, and the acid gastric curve, as a rule, is much higher.

Prognosis.—*Acute Perforation:* If operation is performed within twelve hours of the time of perforation, recovery is usual; if after thirty-six hours, the majority of patients die, although recovery has occurred after diffuse peritonitis has existed for five days or more. A large perforation, a full stomach, and rapid leakage are unfavorable. Minute perforation, an empty stomach, youth, and prompt operation favor recovery. Rather rarely spontaneous occlusion occurs, but this possibility should never be depended upon. Subacute and chronic perforations are not acute emergencies, and do not immediately threaten life. As a rule, however, they continue to give distress until relieved by operation.

Treatment.—Consent having been obtained for an immediate operation,

the pain should be relieved by a hypodermic injection of morphin, the patient quickly prepared, and an upper vertical right transrectus incision made. The small perforation may be obscured by exudate and difficult to locate, especially when on the posterior surface of the stomach with discharge into the lesser peritoneal cavity. The opening is often located by the excess of plastic exudate in its immediate vicinity, the more marked adjacent peritonitis, and the escape of gas or liquid gastric contents from the opening. Occlusion of the opening is accomplished by suture, application of omentum, or, in advanced cases, by gauze packing. Suture may be difficult from the edema and friability of tissues about the ulcer. If the abdomen contains much free fluid and gastric contents a rubber tube should be introduced to the bottom of the pelvis through a suprapubic stab. Irrigation, mopping, evisceration, or any undue manipulation of the general peritoneal surfaces should be avoided. Occlusion of the duodenum or pylorus by suture or inflammation may necessitate an associated gastro-enterostomy. The after-treatment is that for acute septic peritonitis.

Fig. 780.—Doyen's stomach-forceps.

Fig. 781.—Lenhartz' stomach-clamp forceps for gastro-enterostomy.

Secondary Abscess.—A peritoneal or subphrenic abscess may follow perforation of a gastric ulcer.

Carcinoma of the stomach is found superimposed on a gastric ulcer in 15 per cent. of the cases (*ulcus carcinomatosum*). Gastric ulcers over 2 cm. in diameter are presumably malignant, and should be treated by wide excision, cautery destruction, or, better, a partial gastrectomy.

Duodenal Ulcer.—Varieties: (1) Acute; (2) chronic.

Acute duodenal ulcer is occasionally observed after extensive burns, in sepsis and toxic conditions, and may result in perforation. *Chronic* duodenal ulcer is the common form.

Pathology.—Sixty per cent. of peptic ulcers involve the duodenum; 90 per cent. of these, the first 5 cm. of the duodenum, the ulcer being almost unknown below the ampulla of Vater. The ulcers usually are single, and involve the upper

anterior wall at the point of first impact of the ejected acid chyme from the stomach; often the ulcer is so close to the pylorus that the differentiation between a prepyloric gastric ulcer and a duodenal ulcer is only made by noting whether it lies above or below the pyloric vein of Mayo. The ulcers are round or oval, 1 or 2 cm. in diameter; the base smooth, granular, or necrotic, formed of the submucosa, muscularis, peritoneum, or adjacent adherent viscus. The adjacent induration and edema are frequently so great that a tumor-like mass is produced which may be mistaken for a carcinoma. The overlying peritoneum is whitish, cicatricial, thickened, and puckered; the indurated mass and the ulcer crater may be palpated through the duodenal wall. Adhesions and, at times, perforation into the pancreas, liver, gall-bladder, and great omentum are common.

Etiology.—1. *Sex:* Males are four times as frequently affected as females. The duodenum has a more transverse position in women, giving better contact with the neutralizing bile and pancreatic juice (W. Mayo).

2. *Age:* Most common between the ages of twenty-five and forty-five, and very rare at the extremes of life.

3. *Heredity* apparently has no influence, but the disease is one of civilization and of the white race.

4. *Season* and *Occupation:* Exacerbations usually occur in winter-time, under conditions of activity and nervous strain, and are often relieved in the summer months by vacation and relaxation.

5. *Focal* and *alimentary infection* are often associated, especially oral sepsis, chronic appendicitis, and chronic infections of the gall-bladder.

Fig. 782.—Duodenal ulcer deformity, superior surface of duodenum (Carman).

Symptoms.—In the latent or mild type the symptoms cause little disability and often are ignored by the patient, who considers himself in good health until a complication, such as hemorrhage or perforation, occurs. Only on careful interrogation is evidence of previous digestive disturbance then found.

The *pain* of uncomplicated duodenal ulcer is not severe, and does not require opiates or confinement to bed. There is quantitative dyspepsia, the amount of food influencing the patient's comfort more than the character of the food, although acid or fried foods may increase the distress. The appetite is good, but the patient refrains from eating, fearing the secondary distress. The food gives a period of relief of from two to four hours (*food-ease*), followed by distress (*hunger-pain*), which is again relieved when food is taken.

The symptoms in the early months of the disease have a rhythm, periodicity, and regularity (Moynihan). The rhythm being (1) food; (2) ease; (3) pain; (4) ease; the periodicity being shown by pain at about 11 A. M., 4 P. M., and between 11 and 1 o'clock at night. As the distress is relieved by food or alkalies, the patient may keep milk or crackers by his bedside to be taken at night when the distress appears. After the condition has persisted for several years, the rhythm, periodicity, and regularity of the symptoms may be modified or absent.

The attack continues with daily regularity for from six weeks to three months, especially in the fall, winter, and early spring, often with cessation during summer and vacation time.

The distress is characterized by fulness, heaviness, heart-burn, with possible burning or bitter eructations. It is not relieved by vomiting, as it is by food or alkali. Vomiting is rare, the patient may be thin, but is not markedly wasted, pallor suggests that the ulcer is or has been bleeding. Violent pain usually indicates a perforation.

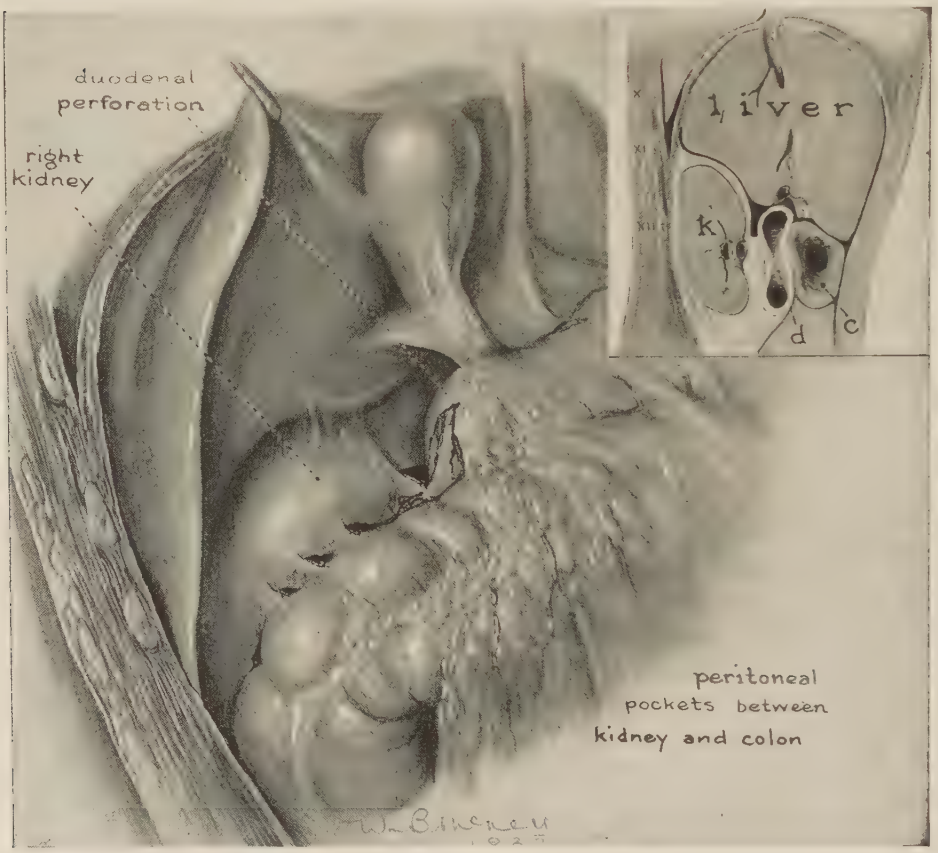


Fig. 783.—Perforated duodenal ulcer: The escaping fluid gravitates to the right lumbar fossa into the pockets between the kidney and colon and about the appendix. The local signs may simulate those of acute appendicitis. The perforation usually is very small, rarely over a few millimeters in diameter. *k*, Kidney; *d*, duodenum; *c*, colon.

Physical Examination.—Palpation gives increased tension of the upper right rectus muscle; deep pressure, tenderness at Robson's point or in the epigastrium. There may be hyperesthesia of the skin, and the pain may radiate posteriorly to the region of the eleventh rib close to the spine.

The test-meal shows an excess of free and combined acid. Occult blood may constantly be found in the stools.

Roentgen evidence after a barium meal includes gastric hyperperistalsis,

rapid emptying of the stomach, deformity of the duodenal cap, the ulcer crater, or evidence of adhesions with tenderness over the duodenal cap.

Complications.—*Hemorrhage* occurs chiefly from ulcers of the posterior wall of the duodenum involving the superior pancreaticoduodenal and gastroduodenal arteries. It is more dangerous than from gastric ulcer, but rarely fatal. The weakness, pallor, and air-hunger may be sufficiently intense to cause the patient to fall in a faint while at work, and is succeeded after twelve or more hours by one or several offensive tarry bowel movements. Often the patient has repeated hemorrhages, the attacks of weakness and tendency to syncope being

Fig. 784.—Posterior gastro-enterostomy, von Hacker's operation, opening in the transverse mesocolon between vessels exposing the posterior surface of the stomach.

attributed to heart disease or other cause, and the secondary offensive tarry stools not attracting attention. Only occasionally is the blood regurgitated into the stomach and vomited.

Perforation.—Posterior perforations are walled off by the pancreas or other structure, and may produce no unusual symptom. Anterior perforation is more frequent and more fatal from lack of localization than perforation in gastric ulcer. The duodenal fluid gravitates at once to the right iliac fossa, producing here intense pain, tenderness, and localized resistance, so that the condition is frequently mistaken for acute appendicitis. The error may be confirmed at op-

eration by the intensely injected peritoneal coat of the appendix. The quantity of fluid, its mucilaginous character, and the diffuse intense injection of the peritoneum, not limited to the appendix, should direct attention to the upper abdomen. The presence of gas or bile in the fluid is significant.

If the patient is in good general condition, the perforation may be enfolded by suture and a gastro-enterostomy done; if the peritonitis is advanced and the patient's general condition poor, or if the local conditions prevent a satisfactory suture, the area of perforation should be carefully occluded by gauze packs and drained, no suture being attempted. Usually it is desirable to provide a vent for the excess of gastric fluid in the abdominal cavity, which may be done by a soft rubber drainage-tube through a suprapubic stab.

Pyloric occlusion with secondary vomiting and dilatation of the stomach occurs either from cicatricial contraction, or from the swelling and edema associated with an ulcer.

Fig. 785.—Gastro-enterostomy: The transverse colon and most of the stomach have been returned to the abdomen. Isoperistaltic alignment of duodenum with stomach. A short duodenal loop from Treitz' ligament, neither redundant nor so short as to drag upon the stomach when it empties or fills, is used. The vertical line on the stomach has been rotated to a transverse position.

Rare complications are the occlusions of bile-duct with jaundice and stone formation, or pancreatitis from invasion of the pancreas or occlusion of the pancreatic duct.

Duodenal ulcer does not predispose to cancer, and primary cancer of the duodenum is almost unknown.

Diagnosis of Duodenal Ulcer.—The clearest and most reliable evidence of duodenal ulcer is often derived from the patient's history; confirmatory evidence may be obtained from the gastric or duodenal tube, the Roentgen examination, and the finding of occult blood in the stools. A tender mass formed by the ulcer and upper right rectus rigidity may be present.

As contrasted with gastric ulcer, duodenal ulcer shows a longer period of food-ease, and a more definite rhythm and periodicity.

Peptic (gastric and duodenal) ulcer should be differentiated from:

1. *Cholecystitis and Gall-stones.*—Associated with qualitative and not quantitative dyspepsia. "Food-ease" and "hunger-pain" are absent, gall-stone attacks are severe, continuous, often relieved by vomiting, and last but a few hours. Acute cholecystitis lasts but a few days rather than six to twelve weeks. The pain of ulcer is rarely severe except from perforation, and attacks occur with rhythm and periodicity and are relieved by food. Cholecystic attacks often require the use of an opiate, abstention from food, and tend to be nocturnal. The ulcer patient is usually a thin, lean, active man; the gall-bladder patient, an obese woman who has borne children.

2. *Appendicitis.*—With the dyspepsia that occurs in chronic appendicitis, the distress usually appears soon after eating, is influenced by the quality of food, and often associated with attacks of intestinal colic, and pain, tenderness, and resistance at McBurney's point.

3. *Cancer of the stomach*, engrafted upon a pre-existing ulcer, may be difficult of diagnosis; the increased severity of the symptoms are of a continuous nature, and lack of relief from food, the loss of appetite, and progressive decline

Fig. 786.—Gastro-enterostomy: To avoid axial rotation in suturing it is desirable to first scratch the lines of proposed incisions upon the stomach and duodenum.

of the patient are significant. Heart disease may be suggested by the recurrent attacks of weakness or collapse from hemorrhage into the intestines; the patient having sudden attacks of weakness or fainting while at work, in the theatre, or elsewhere. The evidence of acute anemia, and the secondary very offensive dark or tarry stools are differential. Cancer of the stomach or pancreas does not give the chronic history or the severe hemorrhages.

In operating, the large firm mass in the upper duodenum produced by an ulcer may be mistaken for cancer. It is to be remembered that cancer rarely affects the first part of the duodenum. Such inflammatory masses usually disappear after gastro-enterostomy.

4. *Pulmonary tuberculosis* is associated with a distaste for food and loss of appetite, there is absence of "hunger-pain" and "food-ease," and evidence of disease within the chest. However, pulmonary tuberculosis coexists with peptic ulcer in 20 per cent. of the cases.

5. *Locomotor Ataxia.*—Many gastro-enterostomies have been done for the gastric crises of tabes, in the belief that an ulcer was responsible for the symp-

toms. The pains are of a lightning-like type, lack the periodicity and relation to food of ulcer pains, and are associated with other evidence of syphilis, although they may occur before the loss of knee-jerks or the development of the Argyll-Robertson pupil, and the blood Wassermann may be negative.

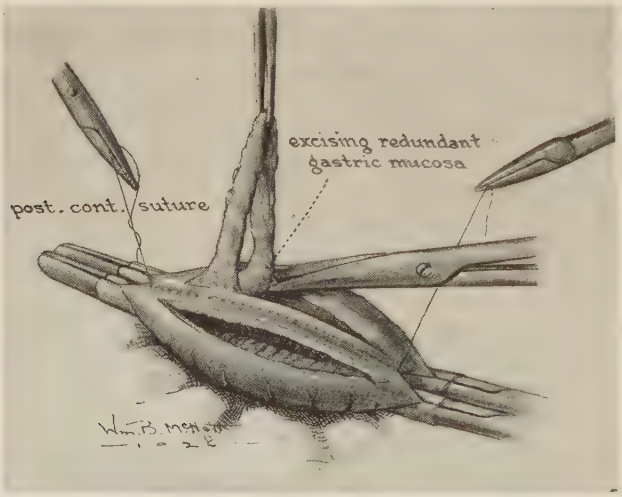


Fig. 787.—Gastro-enterostomy: The posterior part of the continuous seroserous suture nas been introduced, incisions have been made in the stomach and duodenum, and redundant mucosa is being excised by scissors.

Treatment.—Chronic duodenal ulcer is less amenable to medical and dietetic treatment than gastric ulcer, but more amenable to operation. About 87 per cent. (Balfour) of the ulcers heal after a properly performed posterior gastro-enterostomy, which is the simplest and safest effective form of operative treatment.

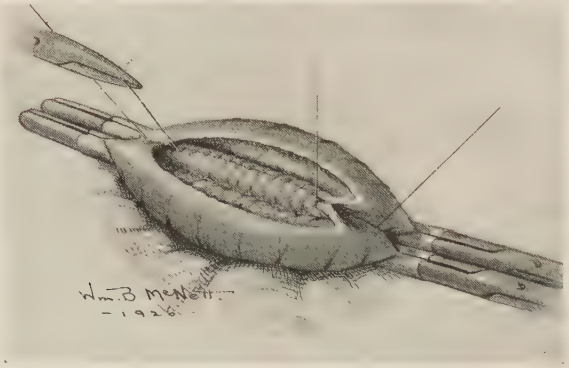


Fig. 788.—Gastro-enterostomy with clamps and continuous suture: The posterior row of seroserous sutures in place, the posterior continuous through-and-through suture uniting the mucous edges is being completed.

An associated occlusion of the pylorus is unnecessary, and an associated excision or cauterization of the ulcer complicates and increases the danger of the operation.

The pyloroplasty of Finney with an associated excision of the ulcer and the pyloroplasty of J. Shelton Horsley (which resembles that of Heinecke-Mikulicz, except that two-thirds of the longitudinal incision is upon the gastric side) are somewhat more difficult, especially with local adhesions and infiltration, give a somewhat greater tendency to secondary hemorrhage, and, while useful, have not displaced the operation of gastro-enterostomy.

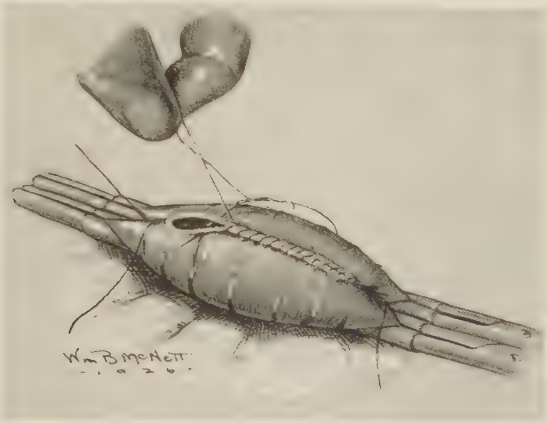


Fig. 789.—Gastro-enterostomy: The continuous through-and-through suture uniting the mucous edges is being completed anteriorly. With the anterior row the mucous edges may be inverted or, as here shown, everted to better control hemorrhage.

For certain resistant, recurrent, or complicated ulcers of the duodenum, the more difficult operation of pylorectomy or partial gastrectomy with the removal of the upper portion of the duodenum is advisable.

Jejunal ulcer (*marginal ulcer, gastro-enterostomy ulcer*) is an ulcer of the jejunum along the stoma produced by gastro-enterostomy.

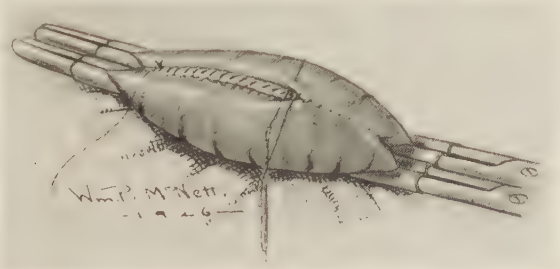


Fig. 790.—Gastro-enterostomy: Completion of the continuous seroserous suture anteriorly; before this row is inserted the clamps should be opened that bleeding along the mucous edges may be shown and corrected.

Etiology.—From 2 to 10 per cent. of gastro-enterostomies are followed by marginal ulcer. In order of frequency it occurs after: (1) The Roux operation *en* Y; (2) the anterior long-loop gastro-enterostomy; (3) the posterior short-loop gastro-enterostomy; (4) it is practically unknown after gastroduodenostomy. The incidence, therefore, diminishes with the amount and concentration

of the alkaline bile and pancreatic fluid about the new opening. If bile and pancreatic juices are prevented from reaching the new stoma in dogs, ulceration usually occurs within six weeks.

The use of non-absorbable suture material, such as linen or silk, which remains as a foreign body, may favor the ulceration.

Symptoms are similar to those of an ulcer of the pyloric antrum or duodenum. After gastro-enterostomy performed for ulcer, the patient usually has relief for two to six months or longer, when symptoms resembling or being more severe than those previously suffered develop. Distress occurs from one to two hours after eating, and the condition tends to persist and to increase despite

Fig. 791.—Gastro-enterostomy (completed): The edges of the opening in the transverse mesocolon have been united to the posterior wall of the stomach about the anastomosis by fine interrupted sutures.

treatment. The tender mass and overlying resistance of the anterior abdominal wall may be felt under the upper left rectus at the site of the anastomosis.

A perforation into the transverse colon or other viscus or into the abdominal cavity may occur. Perforation into the colon is followed by the eructations of fetid fecal gas and, at times, by true fecal vomiting; colored enemas given may be vomited, or lientery occur, in which food is passed by rectum soon after being eaten, with little evidence of digestion.

Prognosis.—Marginal ulcer is persistent and progressive, tending to perforate or cause other serious complication, resisting medication and diet, and should always be treated by operation.

Treatment.—If the original ulcer has healed, the stomach and jejunum at the point of anastomosis should be separated, the ulcer excised, and the opening in each viscus closed separately. If the ulcer for which the original operation was performed still persists, the stomach and jejunum should be separated and closed with excision of the marginal ulcer, and a partial gastrectomy done. Less efficient is the resection of the ulcerated portion of jejunum with the Y anastomosis of Roux, or a gastro-enterostomy, using another section of the jejunum.

Jejunal Obstruction Following Gastro-enterostomy.—*Vicious Circle:* An angulation or spur formation, a slight longitudinal torsion or twist of the jejunum in gastrojejunostomy, or the entrance of a loop of jejunum into the lesser peritoneal cavity is followed by obstruction or vicious circle. The food passes out through the pylorus, only to re-enter the stomach through the abnormal

Fig. 792.—Posterior gastro-enterostomy showing the dependent large stoma, absence of angulation, lines of suture (*b, b'*), and closure of the lesser peritoneal cavity (*a, a'*).

stoma. There is repeated vomiting of bile, food, and duodenal contents, and the patient rapidly wastes and may die from the high intestinal obstruction. These conditions should be prevented by making the anastomosis on a straight line directly opposite the mesenteric border of the jejunum, avoiding too short or too long a loop, and carefully sewing the edges of the opening into the lesser peritoneal cavity to the posterior wall of the stomach.

Treatment of Complications of Gastro-enterostomy.—1. *Vicious circle:* Fowler's position, use of solid food, such as boiled rice, crackers, toast. Repeated introduction of the stomach- or duodenal-tube (lavage) to keep the stomach empty between the digestive periods. If severe and not relieved—*reoperation* with: (a) Review of gastro-enterostomy, relieving constriction, kink, or twist; (b) entero-entero-anastomosis, between afferent and efferent loops; (c) occlusion

or disconnection of pylorus; (d) in chronic forms with patient in fair general condition—Roux *en* Y gastro-enterostomy, or (e) partial gastrectomy.

2. *Hemorrhage* into the stomach and bowel; Fowler's position, ice-cap to epigastrium, 10 c.c. of 5 per cent. calcium chlorid intravenously; 10 c.c. of horse-serum or thromboplastin intramuscularly; 1/6 grain of morphin, 1/60 grain of atropin, hypodermically; lavage with hot (120° F.) water; thromboplastin, 10 grains every two hours by mouth. Stimulation is to be avoided. If bleeding is severe or progressive, the abdomen should be reopened and bleeding points occluded by suture or ligature.

3. *Leakage* or pulling apart of the organs at the line of anastomosis, not infrequent under the old method of anastomosis with the Murphy button, is

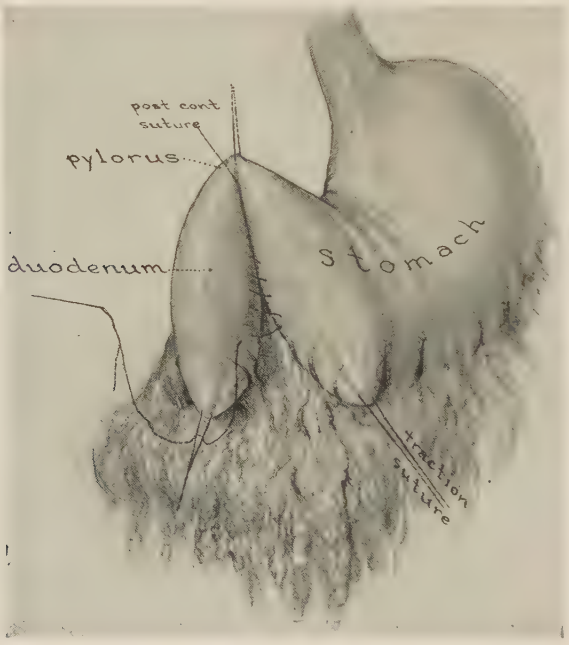


Fig. 793.—Finney pyloroplasty, using continuous sutures: The posterior row of seroserous sutures uniting the stomach and duodenum being inserted.

almost unknown after careful suture unless a relatively fresh line of anastomosis has been reopened and resutured during the stage of edema and healing.

4. *Dumping stomach* (Willys Andrews) in which the food is emptied rapidly through the new opening, producing intestinal distention, discomfort and colic, is treated by small frequent meals and, if not controlled, the line of anastomosis should be disconnected and a different form of operation, such as pyloroplasty or pylorectomy, substituted.

5. *Contraction of the New Orifice.*—The opening should be 5 cm. or more in length to allow for possible contraction. Contraction may be followed by return of symptoms or, if the pylorus is obstructed, by the signs of unrelieved pyloric obstruction. It should be treated by reoperation with enlargement of orifice or other type of operation.

6. *Secondary marginal* or *jejunal ulcer* is to be treated as previously described.

7. *Intestinal obstruction* may occur from herniation of bowel through the opening in the transverse mesocolon into the lesser peritoneal cavity. Nearly all of the small intestines may enter the lesser peritoneal cavity, protrude through the gastrocolic omentum, and hang in front of the transverse colon. This, as well as secondary adhesions, should be relieved by reoperation.

8. *Pulmonary complications* (congestion, pneumonia) are relatively common after operation upon the stomach. A suppository of quinin sulphate (10 grains) should be given by rectum every one or two hours until tinnitus is produced.

9. *Intussusception* of intestine through the stoma, either afferent or efferent, is rare and should be corrected by prompt operation.

Hematemesis (*gastrorrhagia, gastrectasis, hemorrhage from the stomach*) may be: (1) Capillary; (2) venous; or (3) arterial. The bleeding is *frank* or *occult.*

Fig. 794.—Finney pyloroplasty: The first row of sutures in place, line of incision in stomach and duodenum shown.

Etiology.—(1) Peptic ulcer; (2) varices of the stomach, esophagus, or duodenum (especially in cirrhosis of the liver and Banti's disease), portal congestion; (3) cancer of the stomach; (4) ingested caustics; (5) foreign bodies, producing erosion or laceration; (6) toxemia from anesthetics, yellow fever, scorbutus, leukemia, chronic alcoholism, severe exanthemata, as smallpox; (7) aneurysm; (8) vicarious menstruation, hemophilia.

Symptoms.—Pallor, rapid pulse, air-hunger, syncope, cold sweats, collapse, blindness, rarely convulsions, hemiplegia, or blindness; with nausea, vomiting of blood and, later, tarry stools. The blood is vomited and may be mixed with food. It is black (coffee-grounds), acid, airless, fluid or clotted, and the hemorrhage is followed by melena.

Diagnosis.—In hemoptysis there is evidence of pulmonary or cardiac disease, the blood is coughed up, is frothy, bright red, alkaline, fluid, and is preceded and followed by cough and blood râles.

Swallowed blood and malingering should be differentiated.

Prognosis.—Hemorrhage from a gastric or duodenal ulcer usually is acute and violent, 500 to 2000 c.c. of blood often being lost. Hemorrhage from a duodenal ulcer is more dangerous than from a gastric ulcer. Death occurs in from 3 to 5 per cent. Profuse hemorrhage also comes from the erosion of varicose veins of the lower esophagus and cardia in cirrhosis of the liver or splenic anemia; or rarely from a ruptured aneurysm. Hemorrhage from varices in leukemia, in pernicious anemia, or from aneurysm is often fatal. Hemorrhage from cancer is continuous or intermittent, small or moderate in amount, and rarely directly fatal.

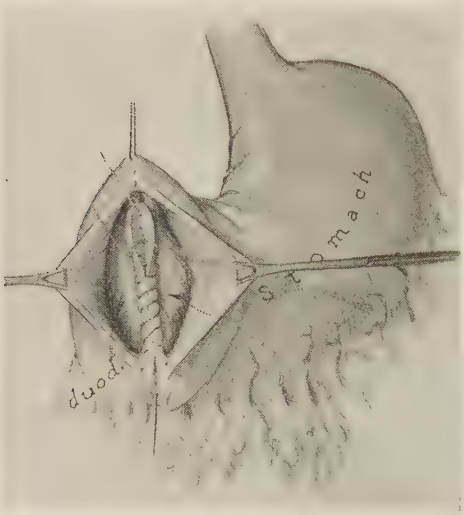


Fig. 795.—Finney pyloroplasty: The posterior row of continuous seroserous sutures is in place, the second row of continuous through-and-through sutures uniting the mucous edges is being inserted. In the original operation interrupted sutures were used.

Treatment.—1. Fowler's position.

2. Absolute rest and starvation.

3. Ice-cap to epigastrium.

4. Lavage with hot water (120° F.) or astringent solutions.

5. Drugs: (a) By vein—calcium chlorid, 10 c.c. of 5 per cent. solution; (b) subcutaneously—atropin, 1/50 to 1/100 grain; thromboplastin; (c) by mouth (often to be avoided as causing emesis)—tannic acid, turpentine emulsion, thromboplastin, adrenalin, tincture of iron, Monsel's solution; (d) avoid stimulants.

Acute dilatation of the stomach usually follows abdominal operation and general anesthesia, especially operations upon the gall-bladder, appendix, and pelvic organs or, more rarely, upon the stomach or kidneys. In one-fourth of the cases the condition is not postoperative, but follows: (1) Acute or chronic severe illness, such as pneumonia (after the crisis), typhoid fever, chronic nephritis, diabetes; (2) abdominal injury; (3) injury of the head or spine; (4) very large meal.

Pathology.—The stomach is enormously distended and thin, the duodenum usually also being distended to the third portion. The obstruction may arise from pressure of the superior mesenteric vessels upon the duodenum, from kinking of the duodenum, or from pressure on the duodenum by the distended stomach. The usual condition is probably a primary paralysis of the muscular walls of the stomach, due to injury or distention, reflex or toxic causes, followed by secondary obstructive pressure on the duodenum.

Symptoms usually develop on the second or third day after operation, with pain, epigastric distention, and vomiting—first of the contents of the stomach, then bile-stained, and finally black or brownish fluid in large quantities. There is succussion-splash and large quantities of fluid, and gas may be evacuated by

the stomach-tube, but the distention rapidly recurs. Alkalosis and fall in plasma-chlorids is associated.

Prognosis.—The mortality is 50 to 75 per cent.; the pulse increases in rapidity, and the patient goes into collapse and dies.

Treatment.—Frequent evacuation of the stomach by stomach-tube; epinephrin, eserin, and pituitrin given subcutaneously, sodium chlorid in salt solution intravenously and subcutaneously; enemas of milk of asafetida. Prone position, with the hips raised, being continued as long as the patient's condition will permit. Jejunostomy.

Gastrectasis (Chronic Dilatation of the Stomach, Atony of the Stomach, Motor Insufficiency of Stomach).—**Varieties:** (1) Primary (atonic), due to loss of muscular tone, with relaxation and stretching of the walls of the stomach; (2) secondary, following pyloric obstruction.

Fig. 796.—Schlesinger's classification of stomachs according to tone: I, Hypertonic (cow-horn). II, Orthotonic (fish-hook). III, Hypotonic. IV, Atonic (dilated and ptosed). (Carman.)

Pathology.—The stomach is enlarged, having a capacity over 1000 c.c. Ptosis of the stomach and weakness, and diastasis of the abdominal muscles are frequently associated.

Etiology.—Middle life (over forty years), female sex, general weakness or asthenia, chronic catarrh of the stomach, repeated overdistention of the stomach (beer drinkers, gluttons), foreign bodies in the stomach.

Symptoms.—Chronic dyspepsia, epigastric discomfort, normal or deficient appetite, flatulent distention, rarely vomiting, general malnutrition, constipation, and tetany in extreme cases. The abdomen is protuberant at navel and epigastrium, the abdominal walls relaxed, the recti separated, and the area of gastric tympany after inflation increased, while a succussion-splash is found two hours or more after meals.

Chemistry.—Reduction in free HCl is usual, with normal or increased total acidity from the increase of organic acids.

Roentgen examination shows a low and enlarged greater curvature, dimin-

ished peristalsis, retention beyond eight hours, with the duodenal cap absent or poorly shown.

Diagnosis.—A motor meal containing raisins remains in the stomach, and may be lifted by tube after eight or more hours. The Roentgen findings are characteristic, showing a hypotonic or atonic dilation of the stomach.

Treatment.—Lavage daily; with regular, small, digestible, and nourishing meals, using food that stimulates gastric secretion and peristalsis, and avoiding bulky food, carbohydrates, fat, and liquids. Abdominal massage, a supporting abdominal belt, and directed exercise are valuable.

Operation: Gastroplication or plaiting of the gastric wall is unphysiologic; gastro-enterostomy is not advisable in atonic gastrectasis, but is indicated in dilatation due to mechanical obstruction.

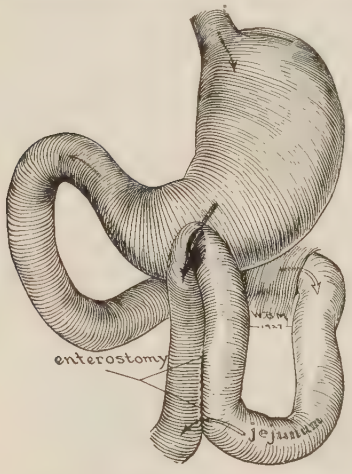


Fig. 797.—Anterior gastro-enterostomy, Wölfler's operation combined with entero-enterostomy to prevent vicious circle. Used when a posterior gastro-enterostomy is not feasible. A loop of jejunum 50 cm. long is required to pass under the omentum and transverse colon without tension.

Pyloric Obstruction or Stenosis.—Etiology.—(1) Juxtapyloric ulcer; (2) tumor, especially carcinoma; (3) hypertrophy of pyloric muscle; (4) pressure from without by adhesions, organs (right kidney), or tumors (pancreas, liver, gall-bladder, colon).

Pathology.—From pyloric obstruction the stomach may (1) dilate and become thin and atonic or, more rarely, (2) hypertrophy.

Symptoms.—With dilatation there is copious vomiting at irregular intervals, frequently two or three days apart, the vomitus having a sour, offensive odor and separating into three layers: froth, fluid, and macerated food. Substances eaten two or three days previously may be recognized in the vomitus. It differs from the vomitus of primary atony in the absence of bile, and in the acid reaction.

Abdominal examination shows a dilated stomach, epigastric distention, succussion-splash and, at times, visible peristalsis and pyloric mass. Roentgen examination: The barium meal accumulates in a bowl-shaped area, formed by the dilated and depressed greater curvature, with an absent or deformed duodenal cap. Raisins eaten eight or more hours before are brought up with the food.

Treatment.—(1) Diet (Sippy treatment) and daily lavage relieves at least temporarily about 80 per cent. of the cases of pyloric obstruction from inflammation of ulcer. (2) Operation: Gastro-enterostomy, partial gastrectomy, rarely pyloroplasty and separation of adhesions are used, dependent upon the underlying pathology.

Hypertrophy of the stomach occurs from pyloric obstruction, with thickening of the walls of the stomach.

Symptoms.—Discomfort following ingestion of food, with a variable appetite. Vomiting of a moderate amount of food after meals is frequent, and gives relief. On examination, visible peristalsis, succussion-splash, and possibly a

mass at the pylorus are found. The Roentgen study shows powerful peristaltic waves, with a retention of eight hours or more.

Treatment is similar to that for atonic dilatation.

Gastroptosis (Prolapse of the Stomach, Fallen Stomach).—Persons with a long, narrow body often show a low position of the stomach without symptoms. Usually the gastroptosis is a part of a splanchnoptosis, and is found in neurotic women with a multitude of digestive and other symptoms.

The greater curvature may reach the pubis or enter the pelvis. An associated dilatation of the stomach is common.

Treatment should aim to increase the general nutrition and muscular tone, to overcome the neurosis, and support the fallen organ. A carefully fitted belt, corset, or binder may be worn, and special exercises given to develop the abdominal wall. Operation is rarely advisable. A gastrosuspension or gastropexy with shortening of the gastrohepatic ligament by interrupted plaiting sutures (Beyea's operation) is occasionally used, has a limited value, and should not be expected to relieve the patient of the neurosis and general weakness, nor to prevent later symptoms being ascribed to adhesions produced by the operation.

Chronic duodenal stasis and **obstruction** result from prolapse of the stomach and duodenum, with kinking at the duodenojejunal angle over the superior mesenteric artery.

Etiology.—The condition occurs in both sexes between the ages of twenty and sixty years, especially in the fourth decade.

Symptoms are those of recurrent obstruction at the duodenojejunal angle, with attacks of severe upper abdominal pain, followed by exhaustion, dehydration, decrease of blood-chlorids, and vomiting of contents of stomach and duodenum, separated by intervals of complete relief. There may be hyperacidity, with the symptoms of duodenal ulcer, toxic symptoms, or typical neurotic manifestations. Roentgen study shows strangulation or obstruction at the terminal duodenum, with duodenal retention and dilatation.

Treatment.—(1) Regulation of the diet, abdominal support in the form of a belt or corset, duodenal drainage during attacks; (2) operative liberation of bowel at the point of pressure, or retrocolic duodenojejunostomy.

Dilatation of the Duodenum.—Gastromesenteric ileus is a form of high intestinal obstruction, associated with dilatation of duodenum and stomach.

Etiology.—The condition not infrequently follows operations upon the stomach or intestine. The cause may be:

1. Mechanical: (a) Where the bowel has been strangulated or twisted in gastro-enterostomy or other operation; (b) a ptosed or distended cecum making traction through a short mesentery or the small intestine, leading to compression of the third portion of duodenum between the superior mesenteric artery, or the right or middle colic artery, and the underlying spine; (c) postoperative gas-distention with angulation or obstruction involving the duodenum.

2. Obstruction due to peritonitis and paresis of the bowel, as in mesenteric thrombosis and postoperative peritonitis.

3. Reflex obstruction from irritation or disease in the ileocecal region.

Symptoms.—Repeated copious vomiting of gastric and duodenal contents, dehydration, acute toxemia and alkalosis, rapid intense prostration.

Treatment as for duodenal stenosis.

Diverticula of the stomach are uncommon. The traction type occurs from simple penetrating ulcers with perigastritis.

Diverticula of the duodenum are second in frequency to those of stomach, and may be single or multiple, of the traction or pulsion type, and occur usually in the second portion of the duodenum.

Diagnosis from pathologic condition in pancreas or bile-ducts, from ulcer, duodenal stricture, spasm, or dilatation of ampulla of Vater is difficult. Repeated fluoroscopic examinations after the administration of atropin is desirable.

Treatment.—Operative obliteration or resection, if the condition is causing ulceration or symptoms.

Volvulus of Stomach (Berti, 1866).—A rare form of obstruction to the passage of food from the rotation of the stomach through its horizontal or vertical axis.

Varieties.—A. Idiopathic—without evident exciting factor.

Fig. 798.—Ulcer and diverticulum of the stomach, diverticulum at *d*, ulcer at *u* (Carman, Mayo Clinic).

B. Complicating—the volvulus being associated with and due to: (1) Diaphragmatic hernia; (2) tumors of the stomach; (3) hour-glass stomach; (4) perigastritis; (5) abdominal trauma.

Pathology.—The rotation is usually about the horizontal axis, isoperistaltic (from left to right), the greater curvature rotating forward under the left lobe of the liver, the posterior wall of the stomach lying anteriorly. The transverse colon may be carried above the stomach, and occluded at 180 degrees rotation. The pylorus, followed by the cardia, becomes obstructed. The gastrosplenic ligament and great omentum may be torn from the stomach. The stomach distends and may even fill the abomen from ensiform to pubis, raising the diaphragm, and displacing the heart above and to the left. The blood-vessels rarely are strangulated.

Etiology.—The volvulus usually occurs in men of middle age or in childhood. It follows abdominal injury, gastroptosis, relaxation, stretching or rupture of gastric ligaments, dilatation of the stomach, a heavy meal, or loss of splanchnic control. The condition is a great exaggeration of the normal rotation occurring in the filling of the stomach after eating.

Symptoms.—(1) Acute, violent, oppressive pain referred to the upper left abdomen, following injury or a heavy meal; (2) vomiting, followed later by inability to vomit, belch, swallow, or pass the stomach-tube; (3) great abdominal distention, with eversion of costal arches; (4) elevation of diaphragm, with displacement of heart upward and to the right.

Diagnosis.—Vomiting, succeeded by evidence of gastric obstruction and distention, and inability to pass the stomach-tube are characteristic. Acute

Fig. 799.—Gastric ulcer with organic hour-glass stomach. Ulcer and constriction at *a*. The lower loculus of the hour-glass is only partially filled, and the canal joining the two loculi is short, although the thin stream of barium trickling down the lesser curvature gives the impression of a long canal (Carman).

dilatation of the stomach, acute pancreatitis, gastromesenteric ileus, perforative peritonitis, and intestinal obstruction should be differentiated.

Prognosis.—Volvulus is very serious, and usually fatal without operative reduction. In order to untwist the stomach, it is necessary, as a rule, to first empty it by a trocar.

Treatment.—Immediate abdominal section; the stomach is exposed, emptied by trocar, and replaced with a gastropexy, if necessary.

Hour-glass stomach is characterized by a zone of equatorial constriction, dividing the stomach into two loculi. It may be *congenital* or *acquired*. The congenital form is rare; the acquired form results from: (1) Perigastric adhesions; (2) gastric ulcer that is annular or adherent; and (3) cancer of

the stomach. The condition most frequently follows chronic ulcer of the stomach.

Symptoms.—(1) Immediate disappearance of fluid introduced into the stomach; (2) a gush of putrid, sour, or indigested food after cleansing the stomach by lavage; (3) paradoxical dilatation; a succussion-splash being found in the pyloric loculus after siphonage of the cardiac; (4) distention of the cardiac loculus is followed by gradual subsidence, with concomitant distention of the pyloric half, associated with gurgling forcing sounds over the middle of the stomach. The sulcus may be outlined after distention of the stomach by carbon dioxid (Mayo Robson).

The Roentgen examination shows two loculi, persisting despite the administration of belladonna or atropin.

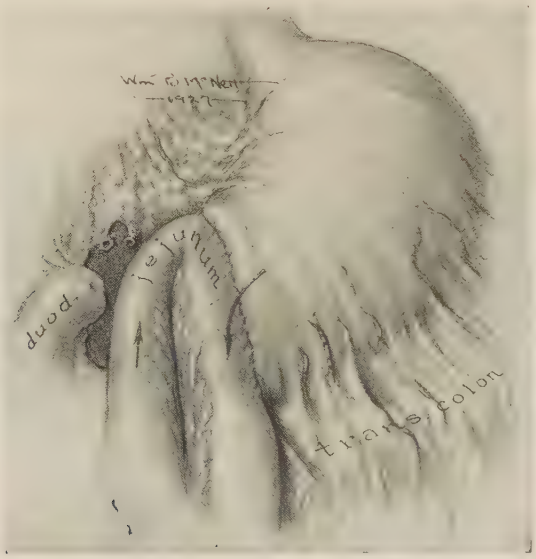


Fig. 800.—Partial gastrectomy by the Reichel-Polya method, end-to-side anticolic anastomosis. This method is time saving and leaves a large stoma.

Treatment.—If the cardiac loculus is large and the pyloric small, a partial gastrectomy may be done, with the removal of the constriction and the pyloric loculus. Partial gastrectomy should also be done for carcinoma or for large ulcers.

With two large loculi a "coat-sleeve" or mesogastric resection or gastro-gastrostomy may be done. In certain instances a gastroplasty or single or double gastro-enterostomy deserves consideration.

Cirrhosis of the Stomach (Leather-bottle Stomach, Linitis Plastica).—Reduction in the size and capacity of the stomach, with marked hyperplasia and thickening of the walls. The stomach may hold but a few ounces of food, the walls being 2 or more centimeters in thickness, the thickening usually being more marked at the pyloric end. (1) *Hyperplastic*, due to diffuse fibrosis, chiefly in the submucosa and, to a lesser degree, in the muscular walls, with but little change in the mucosa. Hyperplasia of the colon, rectum, and ileum may

be associated. (2) *Malignant*, the result of a diffuse carcinomatous infiltration of the gastric wall.

Symptoms, except in the malignant form, are slowly progressive over many years, with vomiting at ever shorter intervals, so that finally even small amounts of food cannot be retained. Epigastric pain, anacidity, progressive emaciation, occasionally slight hematemesis and a firm, smooth, boggy mass in the epigastrium may be present. The Roentgen ray shows great reduction in the size and capacity of the stomach.

In the malignant forms the progress of the disease is much more rapid.

Treatment.—Operative relief is difficult. Recovery has followed complete gastrectomy. Rarely gastro-enterostomy may be feasible.

Hypertrophic stenosis of the pylorus rather rarely occurs in young adults, with pain, distention, and inability to take a full meal.

Treatment is pyloroplasty, pylorectomy, or gastro-enterostomy.

Gastric Tetany.—Stiffness of the voluntary muscles of the extremities, followed by symmetric tonic spasms, with increased excitability of the muscles and nerves to mechanical and electrical stimulation, apparently due to insufficiency of the parathyroid gland and deficient mobile calcium in the body.

Etiology.—(1) *Parathyroid deficiency*—tetany follows removal of the parathyroids; (2) *gastro-intestinal toxemia*—in dilatation of the stomach, gastro-enteritis, cholera, and other severe intestinal infections, absorbed toxic material from the gastro-intestinal tract may produce tetany, unless corrected or neutralized by the parathyroid; (3) *deficiency of calcium*—after parathyroidectomy there is increased calcium excretion, and in tetany the calcium of the blood is diminished. The deficiency of calcium increases the excitability of the nervous system, in which (as in the muscles) no pathologic changes have been found.

Clinical Causes of Tetany.—(1) In marked *dilatation of the stomach* from cancer, ulcer, or other cause. Tetany may follow lavage, percussion of the epigastrium, the use of an enema, or an operation. (2) *Dilatation of the colon*, Hirschsprung's disease, chronic constipation, helminthiasis, in rare instances may be followed by tetany. (3) *Enteritis:* Tetanic spasms are not infrequent after acute enteritis, especially those associated with marked diarrhea, as in cholera, enteric fever, gastro-enteritis of infants, fireman's or stoker's cramp, shoemaker's cramp, and the like. (4) *Disease* or *removal of the parathyroids*, as an accident of thyroidectomy.

Symptoms.—1. *Premonitory Symptoms:* Malaise, drowsiness, formication in in the extremities with a sensation of pins and needles, coldness, heaviness, or muscular stiffness. This may immediately follow vomiting, the use of the stomach-tube, or examination of the stomach.

2. *Tonic Spasms:* Mild forms are limited to the hands and feet, with carpopedal spasm. When severe, the muscles of the extremities, face, neck, jaws, abdomen are involved. The fingers are flexed at the metacarpophalangeal joints, extended at other joints, are pressed together, and the margins of the hand approximated by a spasm of the thenar and hypothenar muscles; the thumb is folded across the palm, or flexed against the forefinger (*accoucheur's hand*), the wrist flexed, the ankles dorsiflexed, and the toes flexed. The spasm usually is somewhat more severe on one side than on the other, and slow writh-

ing movements occur. In severe cases the elbows are flexed, the arms crossed over the chest, the knees extended with the abdomen rigid. In rare cases cyanosis, dyspnea, and spasms of the diaphragm and pharynx occur.

Trousseau's Sign.—Spasms may be produced in the interval between paroxysms by pressure over the nerve-trunks or blood-vessels of a limb, so as to impede the venous or arterial circulation. This continues until the attack is over.

Chvostek's Sign.—Increased mechanical excitability of the motor nerves. Tapping over facial nerve near its point of exit, causing facial spasm.

Erb's Sign.—Increased electrical irritability of motor nerves to both the faradic and galvanic current, especially to anodal stimulation. It is usually demonstrated with the ulnar nerve.

Hoffman's Sign.—Heightened excitability in the sensory nerves, pressure upon which results in paresthesia in the region of their distribution.

Diagnosis.—The premonitory symptoms of tingling, numbness, coldness of the extremities, muscular stiffness, or cramps may attract little attention if they do not progress to a severe tetanic spasm. During a paroxysm the suffering may be intense, and the patient become unconscious or even die. Intermissions during the attack are not unusual.

Prognosis.—In the severe type, the mortality is over 50 per cent., death occurring within a few hours of the first attack or after repeated or prolonged paroxysms.

The **treatment** consists in: (1) Overcoming gastro-intestinal toxemia; (2) maintaining a supply of calcium for the tissues; (3) supplying available parathyroid secretion by subcutaneous injections of parathyroid hormone.

The mortality is especially high with dilatation of the stomach. Ten cubic centimeters of a 5 per cent. solution of calcium chlorid should be given intravenously every six or eight hours, and injections of parathyroid hormone (Collup) used. The toxemia is overcome by repeated gastric and colonic lavage. A Jutte tube may be left in the stomach for constant aspiration. The paroxysm may be instantly relieved by the intravenous injection of calcium chlorid.

In dilation of the stomach a gastro-enterostomy or other operation to overcome obstruction and stagnation should be done as soon as the patient's condition warrants. If there is dehydration, continuous hypodermoclysis should be used.

Syphilis of the Stomach.—Primary and secondary lesions are almost unknown. In the tertiary stage a diffuse infiltrative process of the submucosa and mucosa occurs, or the deposit of gummas with secondary extensive destructive ulcers. Occasionally this also involves the duodenum. Syphilis should be considered whenever multiple ulcers of the stomach are present.

Tuberculosis of the stomach is rare. Miliary and agminate tubercles occur in the mucosa, and may liquefy, leaving ragged precipitous ulcers.

Neuroses of the Stomach (Functional Disturbances of the Stomach):

A. Motor Neuroses.—1. *Vomiting.* Mouthfuls of food are regurgitated without nausea; or vomiting and retching occur, usually immediately following meals, without evidence of gastric disease and with a normal chemistry. This condition may follow mental shock, persist, and, rarely, be fatal.

2. *Flatulence*—air is swallowed (*aërophagia*) and eructed with noisy explosive

sounds, with associated gulping as more air is swallowed. The air may distend the stomach, causing pneumatosis.

3. *Excessive peristalsis*, with borborygmi and much gurgling and rumbling over the abdomen, is very common.

4. *Hypermotility* is characterized by rapid emptying of the stomach, and may occur without other symptoms.

5. *Merycism* (*rumination, cud-chewing*)—food is regurgitated from the stomach into the mouth and reswallowed. The condition is rare, being found in advanced forms of neurosis and in idiots, without involving the general health.

B. Secretory Neuroses.—1. *Hyperchlorhydria* is characterized by an excess of hydrochloric acid in the gastric juice, often found in neurotic women, with epigastric distress and acid eructations, relieved by vomiting, and occurring one-half to two hours after eating.

2. *Gastrosuccorrhea:* A hypersecretion which may be intermittent or continuous and, as a rule, is associated with hyperchlorhydria. (a) Intermittent hypersecretion (*Rossbach's gastroxynsis*) occurs often at night independent of food intake, with epigastric pain, headache, secondary vomiting of acid liquid. (b) Continuous hypersecretions (*Reichmann's disease*) is more common, with constant vomiting and pain, eructations, wasting, dilatation, distention of the stomach by fluid, and an associated pyloric spasm. This condition may be mistaken for carcinoma.

In the intermittent form, solid food should be used; for the continuous type, small frequent meals.

3. *Achylia gastrica nervosa* (*hypochlorhydria*) is not uncommon as a form of nervous dyspepsia, the hydrochloric acid and ferments being reduced, but rarely absent.

C. Sensory Neuroses.—1. *Gastralgia* may occur at the menopause associated with worry and ill-health, or in the neurasthenic and hysteric, or occasionally at puberty. There is no relation to food; vomiting is uncommon. Food may increase or relieve the pain; pressure gives comfort.

2. *Bulimia* (*excessive hunger*) may develop suddenly at night, and lead to dilatation of the stomach; it occurs in the hysteric and neurotic, and also as a symptom of diabetes.

3. *Akoria* (*constant hunger*), the stomach is never filled.

4. *Anorexia nervosa* (*loss of appetite*) is a rare but occasionally fatal form.

5. *Periodical vomiting* (*cyclical vomiting*) usually occurs between the ages of three and ten, and attacks may last three or four weeks. These conditions should carefully be differentiated from the organic diseases of the stomach requiring operation.

TUMORS OF THE STOMACH

Benign tumors of the stomach are rare, and include adenomas, myomas, lymphadenomas, and cystic growths. The adenoma produces a polypoid mass projecting into the stomach, and the myoma may form masses that grow inside or outside of the organ. Hydatid cysts occasionally involve the stomach. Rarely cysts are found between the walls of the stomach or layers of omentum, originating from the growth of aberrant glands.

Symptoms of a benign tumor are dyspepsia and motor irregularity. Vomiting and dilatation may be caused by a pedunculated tumor slipping into the pyloric orifice. In Pepper's case a patient with a polypoid tumor was, for years, obsessed with the thought that he had swallowed a live snake.

Diagnosis may be made or confirmed by Roentgen study, and the tumor may, if large, be palpable through the anterior abdominal wall.

The **treatment** is gastrotomy and excision of the tumor or partial gastrectomy.

Gastric Polyps (Polyposis of the Stomach).—*Varieties:* (1) Polyadenoma—a pedunculated lobulated tumor, congenital or inflammatory, adenomatous, polypoid, or forming elevated and, at times, telangiectatic plaques. (2) Polyadenoma *en nappe*—a raised, well demarcated plaque, not lobulated, cystic or pedunculated, composed of closely placed folds of hypertrophic mucous membrane. There is thickening of the mucosa and diffuse increase and enlargement

Fig. 801.—Angioma of the stomach (Carman).

of the glands. *Discrete polyps* may be pedunculated, spherical, hemispherical, button-like, freely movable on the submucosa with marked thickening of mucosa, and have a core of connective tissue from the submucosa. Brunn and Pearl collected 89 cases of diffuse gastric polyposis from the literature.

Symptoms.—Epigastric distress, distention, vomiting, severe anemia, diarrhea from the anacidity, anorexia, weakness. Hematemesis occurs in 8 per cent.

The gastric analysis shows: (1) Achlorhydria which may last twenty-five years; (2) gastric hemorrhage; blood (occult or manifest) is present in 45 per cent.; (3) tumors, shreds, and particles occur in the washings in 20 per cent.; (4) excessive mucus in 13 per cent.; (5) achylia in 90 per cent. (Brunn and Pearl).

The motility is normal or increased. Roentgenograms show indentations and irregular defects in the margin of the gastric shadow at the site of the tumors, usually upon the greater curvature.

Diagnosis by the roentgenogram, gastroscopy, and the examination of shreds found in the washings. Achylia, myxorrhea, and fresh blood in the contents are suggestive.

Prognosis.—Malignant degeneration occurs in 12 per cent.

Treatment.—Gastrotomy, and removal by excision or the cautery.

Sarcoma of the stomach forms 2 per cent. or less of the tumors of the stomach; usually occurs under the age of twenty-five years, shows rapid growth and large size, without involvement of the mucous membrane or obstruction. Vomiting, hematemesis, and occult blood therefore are usually absent.

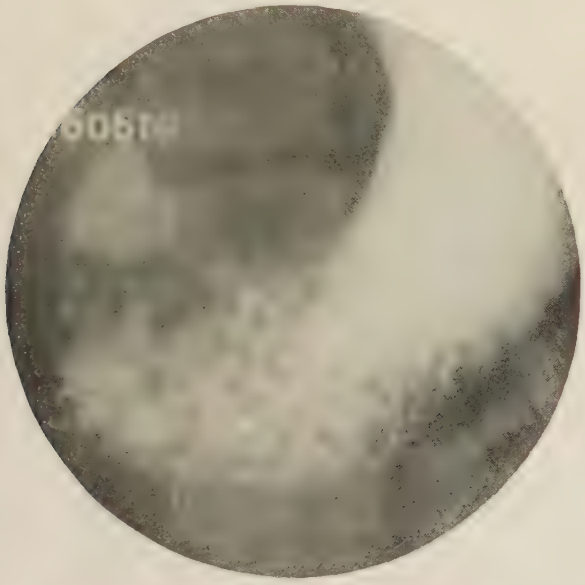


Fig. 802.—Roentgenogram of gastric polyposis (Carman).

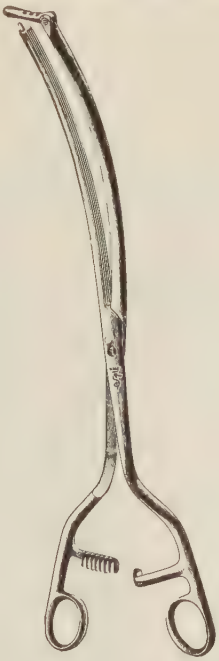


Fig. 803.—Kocher's gastric clamp used in gastrectomy.

Lymphoblastoma of the stomach may on Roentgen examination show filling defects, irregular deformity of the antrum, or negative findings. It may be mistaken for carcinoma.

Treatment.—Partial gastrectomy, radiation.

Carcinoma of the stomach is the most common cancer of an internal organ in men. In women cancer occurs more frequently in the uterus and the breast. Twenty to 40 per cent. of all cancers involve the stomach, and about 3 per cent. of all deaths occur from this disease. It is about twice as frequent in men as women, the age usually is between forty and sixty-five years (average sixty-one years). It is rare under thirty-five. Heredity may predispose.

Cancer of the stomach usually is primary, very rarely secondary to carcinoma of the breast or other organ. External injury, alcohol, and tuberculosis have no clear causal influence.

Relation to Gastric Ulcer.—About 10 to 15 per cent. of gastric ulcers undergo malignant degeneration, and from 10 to 40 per cent. of gastric carcinomas develop on a pre-existing ulcer base.

Site.—Carcinoma of the stomach elects the *Magenstrasse*, involving the pylorus, in 60 per cent.; the lesser curvature in 20 per cent.; the cardia, 8 per cent.; the posterior wall, 5 per cent.; while diffuse or generalized carcinoma of the stomach appears in 5 per cent. The anterior wall, greater curvature, and fundus are rather rarely involved primarily. The usual growth is a hard irregular mass (often annular) at the pyloric antrum, with a tendency to pyloric obstruction. Usually there is an excavated ulcer on the mucous surface, with a rough floor and hard, irregular, everted edges. Infrequently the tumor forms a soft fungating mass projecting into the stomach, with extensive colloid change; or the entire organ is small, thickened, infiltrated, hard and contracted from a diffuse involvement (*leather-bottle stomach, linitis plastica*).

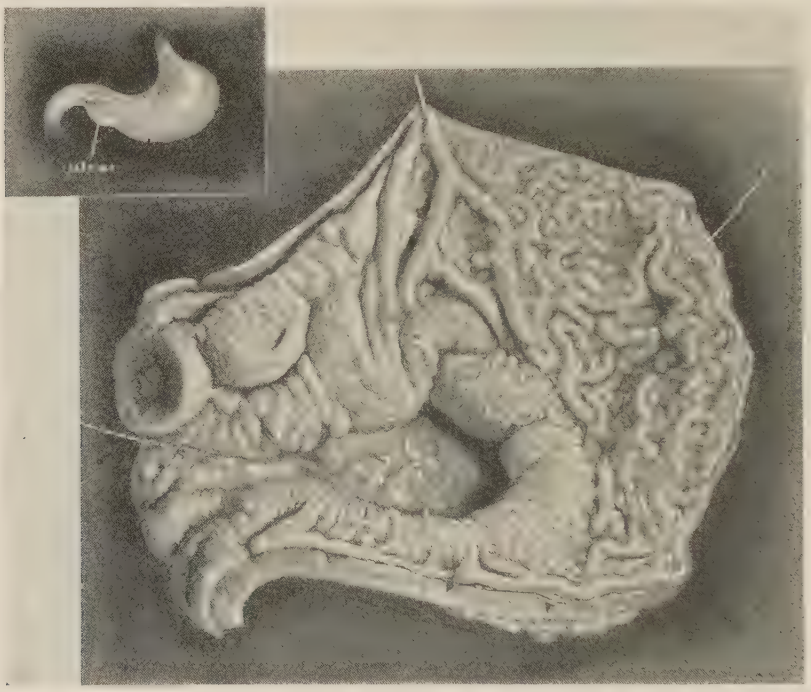


Fig. 804.—Carcinomatous ulcer of the stomach. Chronic gastric ulcers more than 2 cm. in diameter are usually malignant.

Extension.—The growth tends to spread upward from the pylorus along the lesser curvature, or downward from the cardia, but it has no tendency to invade the duodenum.

The primary lymph-drainage of the stomach is away from the cardia and fundus to the nodes, lying in the gastrocolic and gastrohepatic omenta toward the pyloric end of the stomach.

Secondary growths occur in the left supraclavicular lymph-nodes and nodes along the posterior border of the left sternomastoid, by extension along the thoracic duct, the left axillary lymph-nodes, and rarely the inguinal nodes. In about 30 per cent. of the cases secondary growths are found in the liver, and less frequently in the pancreas, lung, pleura and, rather rarely, in the bones,

the brain, spleen, and other organs. Secondary invasion of the aortic lymph-nodes and of the peritoneum (with ascites) is common in the later stages. Nodules may form along the round ligament and navel, in adjacent subcutaneous tissues of the anterior abdominal wall or in the pelvis (*Blumer's rectal shelf*).

Seventy-five per cent. of the tumors are scirrhous in type, forming hard growths, usually near the pylorus, with small acini and few cells; 60 per cent. are spheroidal celled. Less frequent are the *encephaloid* or *medullary carcinomas* —soft, grayish, juicy growths, tending to ulceration and hemorrhage, with many cells and scanty stroma.

Columnar-cell carcinomas constitute about 40 per cent.; form large, moderately firm masses, occasionally ulcerate or are the seat of colloid degen-

Fig. 805.—Medullary carcinoma of the greater curvature shown at *a* (Carman).

eration. Colloid carcinomas often spread to the omentum, forming large masses containing large alveoli filled with colloid material, and containing few epithelial cells.

Squamous-cell carcinoma of the stomach develops in the lower end of the esophagus, and is very rare.

The stomach may be dilated from pyloric occlusion, distorted by infiltration or adhesions (occasionally to an hour-glass form), or greatly contracted as in leather-bottle stomach.

Adhesions are very common, especially to the pancreas, liver, colon, and great omentum.

Symptoms.—1. *Early Stage.*—Clinical picture: A man between the ages of forty and sixty, who has reached his maximum weight, develops digestive symptoms, weakness, and progressive loss of weight. There is loss of appetite, and fulness and distress are referred to the stomach, particularly after eating. In

90 per cent. of the patients a gastric analysis shows reduction in the acid values; in 10 per cent. there is found an excess of hydrochloric acid and of the total acidity. The washings may show an excess of leukocytes and red blood-cells. A mass may or may not be demonstrated by the *x*-ray examination.

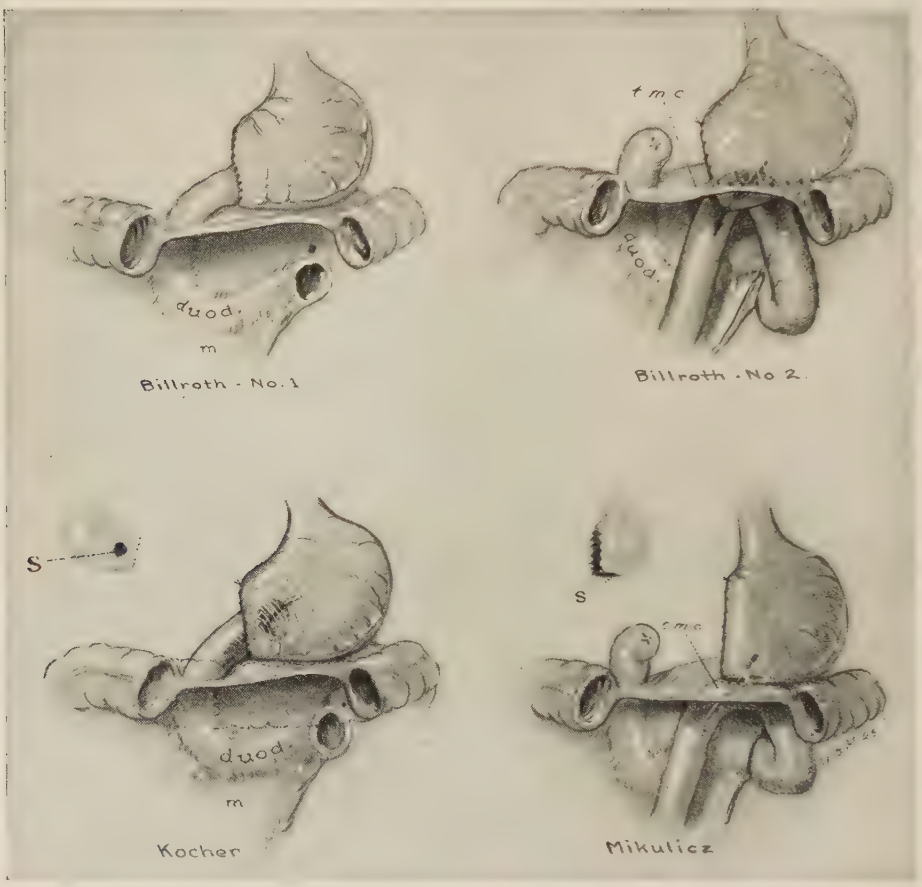


Fig. 806.—Older methods of partial gastrectomy. Billroth I end-to-end union with duodenum anastomosed in lower part of gastric incision. With original technic, this was followed by leakage at so-called "fatal angle." The opening may contract and become occluded. Billroth II. End of stomach and duodenum closed followed by separate anterior—or, as shown, a posterior gastro-jejunostomy. Kocher method. A modification to avoid the fatal angle of Billroth I. End of stomach closed, end of duodenum anastomosed to posterior wall of stomach. Now practically obsolete. Mikulicz' method designed to obtain dependent drainage. End of stomach closed, jejunum anastomosed to adjacent greater curvature. Rarely used. *S.*, Stoma; *t.m.c.*, transverse mesocolon.

This stage is the period of operability.

2. *Second Stage, Fully Developed Symptoms.*—There is constant distaste for food, marked loss of weight and, if the tumor has produced obstruction at the pylorus, the stomach becomes dilated with copious vomiting occurring at intervals; or, if at the cardia, dysphagia and vomiting soon after food is taken. Blood

may be vomited, and occult blood is constantly found in the stools, with progressive emaciation and weakness. A hard mass usually is palpable under the ribs. This is the stage of possible operability.

3. *Third Stage, Terminal Condition.*—There is anorexia, almost constant epigastric pain and distress, with vomiting or regurgitation of foul brownish or blood-stained fluid, great emaciation, cachexia, with lemon-yellow colored skin,

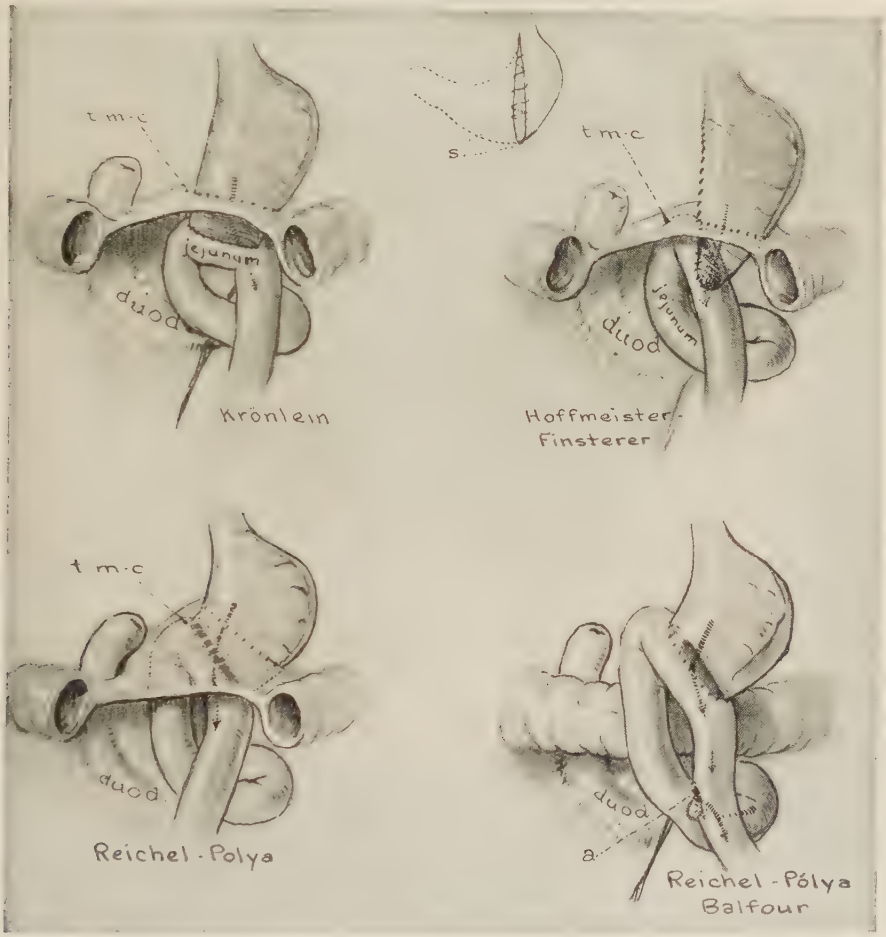


Fig. 807.—More recent methods of partial gastrectomy. Krönlein method, a low section of a narrow stomach was made and the small end of the stomach united to the side of the jejunum. This has been supplanted by the more radical Reichel-Polya and Hoffmeister-Finsterer methods in which care is taken to have the afferent loop of jejunum higher than the efferent. Hoffmeister-Finsterer method, a large, very oblique, gastric resection with removal of part or all of lesser curvature. Large retrocolic anastomosis with edge of lower part of gastric incision united to side of jejunum. Developed for gastric ulcer by Finsterer but considered by many surgeons unnecessarily radical. Reichel-Polya method, an isoperistaltic, retrocolic union of the end of the stomach to the side of the duodenum. Balfour's modification of the Reichel-Polya operation, an isoperistaltic antecolic union of the end of the stomach with the side of the jejunum. Used to avoid the tension and technical difficulties of the retrocolic union, particularly if the residual portion of the stomach is small, high, and rather fixed. To avoid reflux distention of the proximal loop an entero-enterostomy has been added (*a*). *t.m.c.*, Transverse mesocolon; *S.*, stoma.

low hemoglobin, enlargement of the left supraclavicular lymph-nodes, a large nodular liver, abdominal ascites, followed by edema of the legs; the stomach may be greatly contracted or enormously dilated. Secondary growths of the overlying skin in or about the navel may be present, and the growth may become

Fig. 808.—Inoperable carcinoma of the cardia (Carman).

adherent to the skin and ulcerate, forming an external fistula or rupture into the abdominal cavity with secondary peritonitis and death. There is absence of digestive leukocytosis, presence of Oppler-Boas bacilli, coffee-grounds vomit

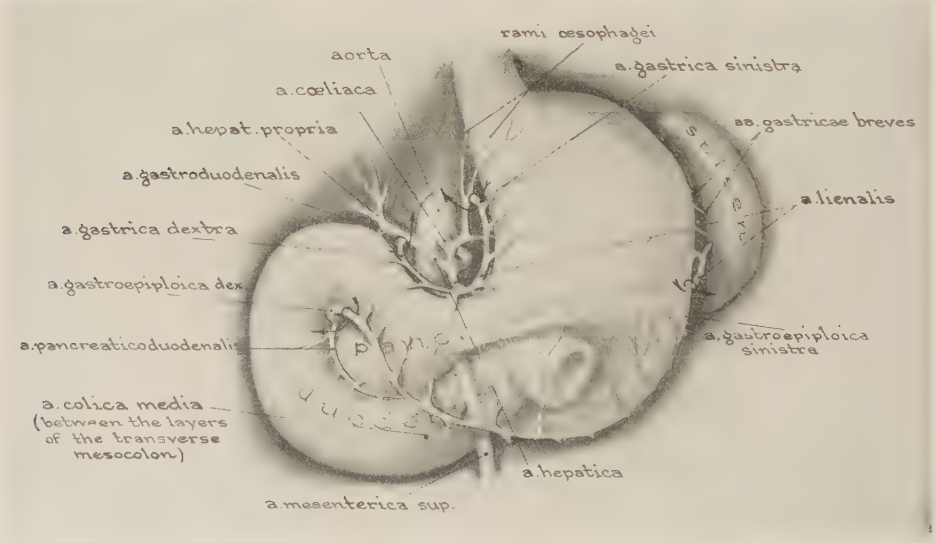


Fig. 809. The arteries of the stomach, indicating their points of ligation in partial gastrectomy.

or, rarely, vomiting of bright red blood. The roentgenogram shows impaired motility with filling defect.

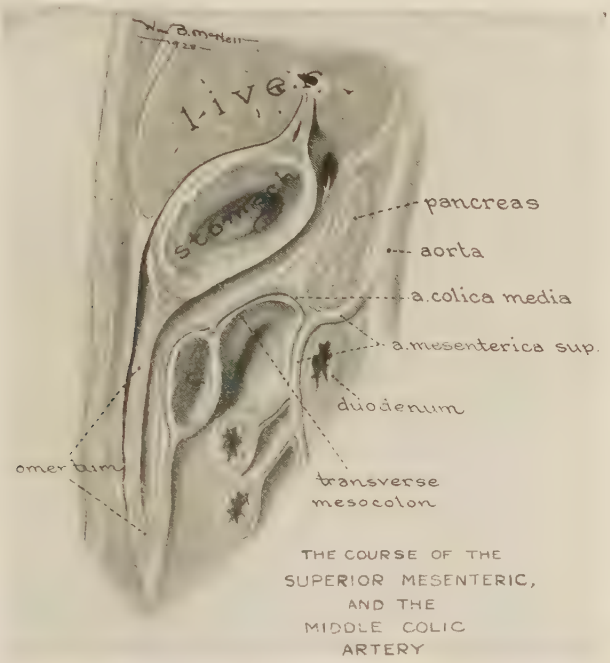


Fig. 810.—Showing proximity of the midcolic artery to the vessels of the great omentum. Accidental ligation of this artery in partial gastrectomy may be followed by gangrene of the transverse colon.

Diagnosis.—In a patient over forty years of age, the onset of dyspepsia without evident cause, associated with progressive weakness and loss of weight, should at once arouse the suspicion of carcinoma of the stomach.

Progressive increase in gastric symptoms in a patient with evidence of old ulcer of the stomach suggests malignant change. If the symptoms do not yield promptly to treatment or if no good reason for the dyspepsia is found, an exploratory operation should be done, irrespective of the chemical and Roentgen diagnosis.

Enlarged craggy left supraclavicular glands, induration about the upper rectum (*Blumer's shelf*), umbilicated nodules in the liver, or ascites indicate an advanced and hopeless condition.

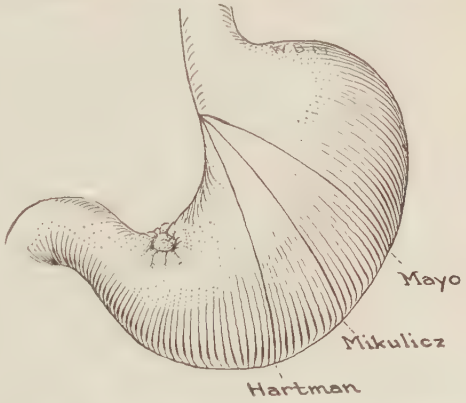


Fig. 811.—Lines for division of the stomach in partial gastrectomy of Hartman, Mikulicz, and Mayo.

Prognosis.—The hope with carcinoma of the stomach lies in an early

partial gastrectomy, which gives freedom from recurrence up to five years in 30 per cent. of the cases, with a primary mortality of 10 per cent. or less

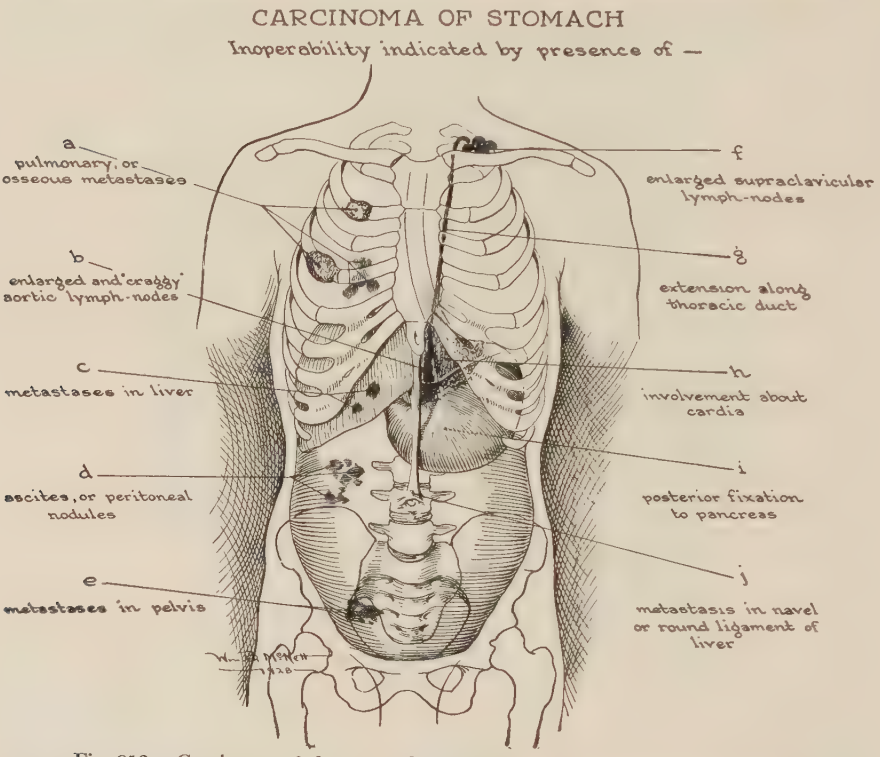


Fig. 812.—Carcinoma of the stomach. Conditions contraindicating excision.

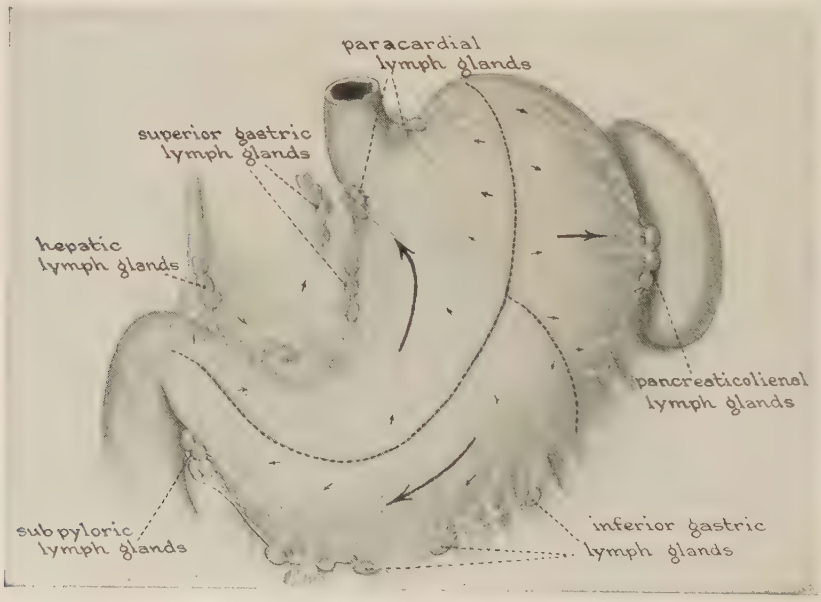


Fig. 813.—Lymphatic drainage of the stomach in relation to partial gastrectomy for cancer.

In the second stage without evidence of metastasis, an exploratory operation should be made to determine the feasibility of a partial gastrectomy or, at least, the desirability of a palliative operation.

The gradual decline and death attributed to old age are frequently due to carcinoma of the stomach.

Treatment.—Operative removal is the only treatment that offers any hope of recovery.

Fig. 814. 1–4, Modifications of Billroth anastomosis designed to give a large stoma. 5, 6, Fränkel-Babcock telescopic anastomosis; not to be used for malignant disease.

Partial gastrectomy is the preferred operation; the infiltrated area of stomach, with a margin of 4 or 5 mm. of normal gastric tissue, being removed with the associated glands and the adjacent gastrocolic and gastrohepatic omenta. Partial gastrectomy is *contraindicated* when there are (1) secondary large, craggy glands about the aorta and celiac axis, or secondary nodules in the liver or other organ; (2) infiltration of the pancreas or liver, and (3) growth about the cardia.

For satisfactory removal, the tumor should be movable, occupy the lower

half of the stomach, and the secondary involvement should be limited to the adjacent primary lymph-nodes.

Gastrectomy in two stages may be selected when there is pyloric obstruction with great debility. A gastro-enterostomy at a point well removed from the

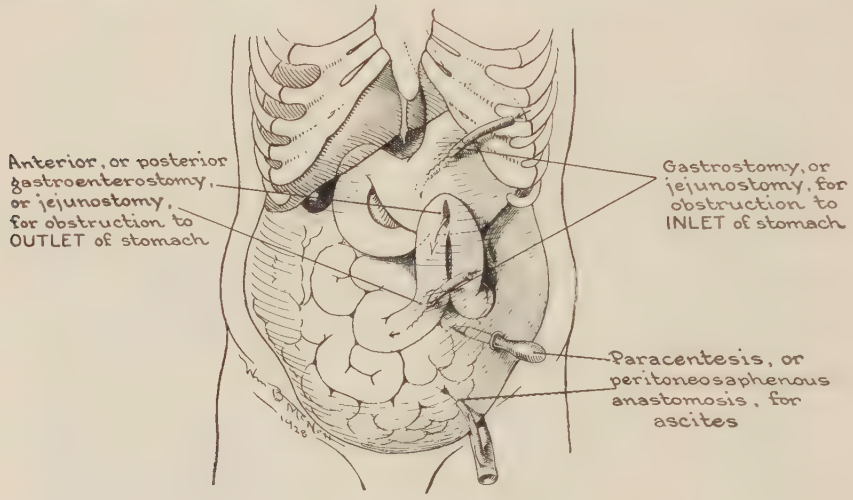

Anterior, or posterior gastroenterostomy, or jejunostomy, for obstruction to OUTLET of stomach
Gastrostomy, or jejunostomy, for obstruction to INLET of stomach
Paracentesis, or peritoneosaphenous anastomosis, for ascites

Fig. 815.—Palliative operations for cancer of the stomach.

growth being done at the first operation, and a partial gastrectomy two or more weeks later. Complete gastrectomy is rarely advisable. While patients have occasionally lived for one or two years after the operation, recurrence has been invariable.

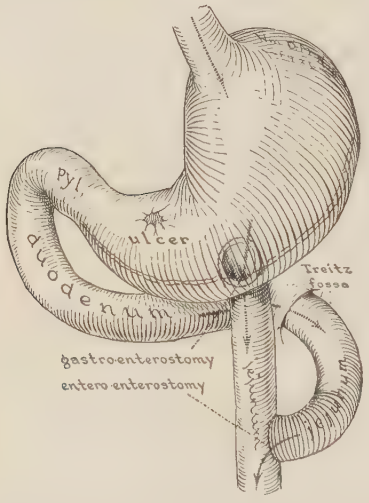


Fig. 816.—Roux's gastro-enterostomy *en Y*, with end-to-side anastomoses.

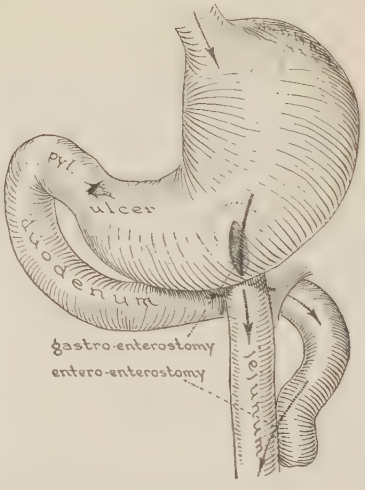


Fig. 817.—Roux's operation of gastro-enterostomy *en Y*, using side-to-side anastomoses.

Palliative operation may be desirable when the growth cannot be removed. For cardiac obstruction, a gastrostomy or jejunostomy may be used; for diffuse infiltration of the stomach, a jejunostomy. With infiltration of the posterior

gastric wall, an anterior gastro-enterostomy is selected. If the growth is ineradicable, a soft light diet of carefully prepared food is usually given in combination with pepsin, bismuth subcarbonate, and creosote. As a local sedative and to reduce pain, sulphonmethane, chlorbutanol, or a mixture of paregoric and spirit of chloroform, is useful in the later stages.

For distention or fermentation, lavage with dilute Dakin's or Condy's fluid may be used. In the final stages sufficient opium (tincture or vinegar of opium), fluidextract of condurango, codein—with or without hyoscyamus or hyoscin—should be given to make the patient comfortable.

Operations upon the Stomach. — Historical. — Gastrostomy was proposed by Egebert in 1837, and first done by Sedillot in 1849. The first successful gastrostomy was by Sydney Jones in 1875. Ssabanajew's gastrostomy was developed in 1890, and independently by Frank (*Ssabanajew-Frank operation*) in 1893. The Witzel operation was devised in 1891; the Stamm operation in 1894; the Kader operation in 1896.

Gastro-enterostomy.—1. *Anterior gastro-enterostomy* (*Wölfler's operation*) was first performed by Wölfler at the suggestion of his assistant, Nicoladoni, in 1881. 2. Posterior gastro-enterostomy (*von Hacker's operation*) was suggested by Courvoisier in 1882. The plan of operation was improved and first used by von Hacker in 1885. The short loop posterior gastro-enterostomy was suggested by Peterson and first used by his chief, Czerny, in 1901. The elastic ligature, introduced by Silvestri in 1862, was perfected and adopted for gastro-enterostomy by McGraw in 1891.

Gastroduodenostomy was done by Jaboulay in 1892. In 1897 gastro-enterostomy *en Y* was devised by Roux.

For the vicious circle following anterior gastro-enterostomy, the closure of the pylorus was suggested by Doyen (1893) and by von Eiselsberg (1895). Later it was found to be of little value. Entero-entero-anastomosis between the afferent and efferent intestinal loops, suggested by Braun (1892) and later in the same year by Jaboulay, is still used with anterior gastro-enterostomy.

Pyloroplasty (*Heineke-Mikulicz operation*) was devised by Heineke in 1886, and by Mikulicz in 1887. In 1902 the more elaborate operation of Finney (Finney's pyloroplasty or gastroduodenoplasty) was published.

Pylorectomy was suggested in 1876 by experiments of Gussenbauer and von Winiwarter on dogs. The first operation was by Pean in 1879; the second by Rydygier in 1880. The first successful pylorectomy was by Billroth (*Billroth's No. I gastrectomy*) in 1881.

Fig. 818. –Doyen's gastric clamp, used in operations on the stomach.

Partial gastrectomy was introduced by Billroth (*Billroth's No. I end-to-end*) in 1881, and modified to Billroth No. II (separate gastro-enterostomy), to avoid the leaking "fatal angle," in 1883. The end of the stomach was implanted into the side of the jejunum by Reichel in 1908, and independently by Polya in 1911. The Reichel-Polya retrocolic operation was modified by Balfour (1917) to an anticolic anastomosis with entero-entero-anastomosis; and in 1920 by Moynihan to a *short loop* anticolic union without entero-entero-anastomosis.

Total gastrectomy was first performed by Connor of Cincinnati in 1883; the first successful operation being by Schlatter of Zurich in 1897. No permanent recovery from a total gastrectomy for cancer has been recorded.

Special Operations for Gastric Ulcer.—Gastro-enterostomy was suggested for the treatment of ulcer by Doyen in 1898. In 1881, Rydygier treated a large ulcer of the posterior wall by resection.

In 1902 Finney developed his pyloroplasty. In 1903 Rodman suggested pylorectomy, or the removal of the ulcer-bearing area. In 1914 cautery destruction of the ulcer was devised by Balfour. In 1919 cholecystogastrostomy was used by Babcock. In recent years, due to its shortcomings, gastro-enterostomy for gastric ulcer has been supplanted in the hands of many surgeons by partial gastrectomy—while gastro-enterostomy continues to be largely used for the treatment of duodenal ulcer. For success there should be efficient drainage and sufficient reduction in the acid gastric curve.

Exploration of Stomach: The stomach is usually explored through an upper vertical transrectus incision, by vision and palpation. The posterior surface of the stomach is exposed through an opening in the gastrohepatic omentum, the gastrocolic omentum, or the the transverse mesocolon, carefully avoiding the blood-vessels. In the intercolo-epiploic route the great omentum is sepa-

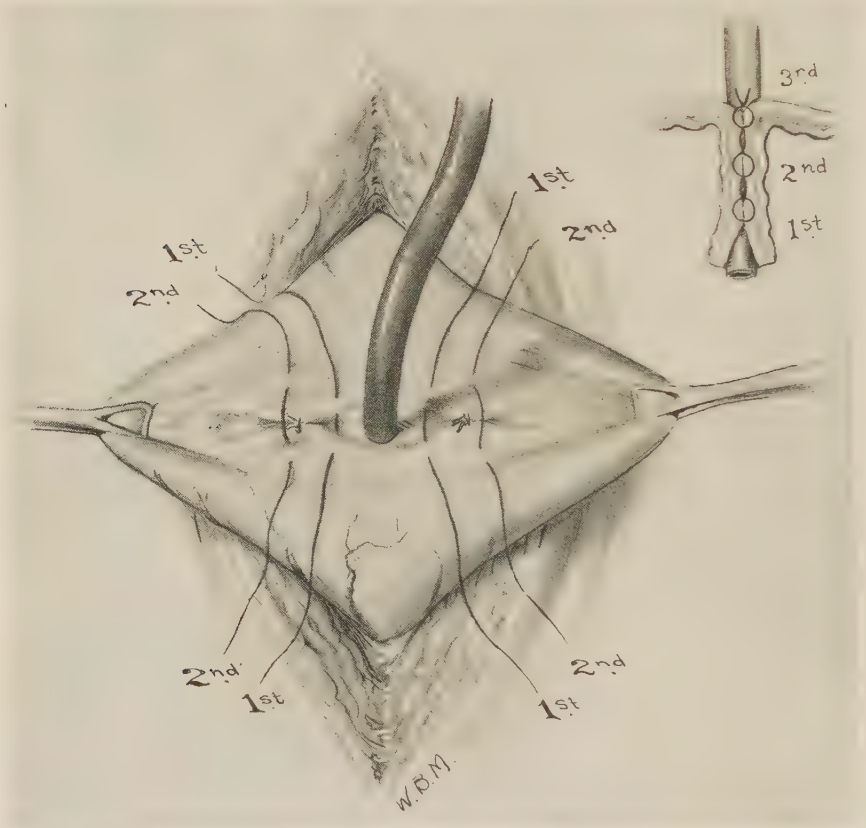


Fig. 819.—Gastrostomy of Kader, gastric wall being inverted about rubber tube inserted and fastened into the anterior wall of the stomach.

rated from the transverse colon, exposing the stomach, duodenum, and pancreas. The important vessels lie on the posterior leaf of the gastrocolic omentum and are not disturbed.

Exploration of the interior of the stomach is accomplished by:

Gastrotomy.—A transverse incision is made through the anterior wall of the stomach by which the mucous lining may be inspected and palpated, foreign bodies removed, an ulcer cauterized or excised, bleeding points occluded, the pylorus or cardia dilated.

Cardiodiosis (Divulsion of Cardia, Mikulicz's Operation).—By an anterior gastrotomy a dilating instrument is introduced into the esophagus, which is stretched up to 6 cm. This operation has been superseded by dilatation from dilators introduced through the mouth.

Pylorodiosis.—*Loreta's Operation:* Dilatation of the pylorus by instruments or finger, introduced through a gastrostomy incision, is of limited value and rarely employed.

Hahn's method of pylorodiosis: The pylorus is dilated by invaginating the anterior gastric wall through the pylorus upon one or more fingers or the thumb. This operation occasionally is used for milder forms of pylorospasm or pyloric contraction. The effects are usually transient.

Gastrostomy.—A more or less permanent external fistulous opening is made into the stomach for feeding or intragastric manipulation. It may be temporary or permanent, is made with a valvular opening to prevent leakage of gastric contents on the skin, and with the formation of a valvular tube (lined by serosa) which later may become epithelialized.

1. *Stamm's Gastrostomy* (1894).—A cone of gastric wall, from the center of which a tube projects into the stomach, is inverted into the stomach by a series of concentric purse-string sutures. The tip of a No. 12 or 14 French soft-rubber catheter is introduced and fastened in a small opening in the stomach by a catgut suture, surrounded by successive purse-string sutures of chromic gut (about 1 cm. apart) until three or four have been introduced and tied. The adjacent gastric wall is fixed to the peritoneum under the incision by two or more sutures to prevent leakage or displacement. The abdominal incision is closed about the tube, and feeding with liquid food may be started at once through the tube.

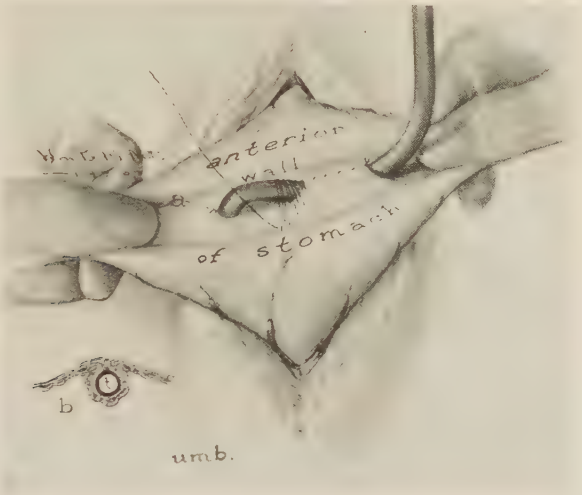


Fig. 820.—Witzel's gastrostomy showing method of implanting a soft-rubber tube or catheter in a plait formed in the anterior wall of the stomach. The suture is continued to the point *a*; *b* shows the tube invaginated in the outer wall of the stomach.

2. *Kader's operation* (1896) resembles the Stamm operation, except that a plait of the gastric wall is enfolded instead of a cone, by superimposed interrupted or continuous sutures.

3. *Witzel's Operation* (1891). The tip of a small rubber catheter is passed through a small hole in the stomach, and fastened by a catgut suture; about 5 cm. of the tube is then buried in the depths of a plait, formed in the wall of the stomach by a continuous or interrupted fine chromic-gut suture. The area of stomach where the tube emerges from the plait is anchored to the parietal peritoneum under the abdominal incision. The abdominal wall is then closed about the tube.

4. *Frank's gastrostomy* (Ssabanajew-Frank) consists in drawing a cone of stomach through a high upper left rectus incision, carrying it through a subcutaneous tunnel, the apex being brought through a short skin incision just above the left costal arch, to the edges of which the open cone is fastened after closing the primary incision 3 or 4 cm. below. The operation requires a considerable area of mobile anterior gastric wall, which often is not available. De Page formed the fistulous mucosa-lined tube from a flap of the anterior gastric wall with the base above. Tabell used a section of jejunum with attached mesentery; Stewart, a flap of skin of the anterior abdominal wall, pedicled above and rolled into a tube which was anastomosed with an opening in the stomach.

Gastrostomy, by forming a channel from skin or mucous membrane, has not sufficient advantages to compensate for the greater difficulty or danger involved.

The Witzel and Stamm operations are simple and satisfactory.

Jejunostomy.—A fistulous opening into the jejunum is used: (1) For purposes of feeding when feeding by mouth or through a gastrostomy opening is not feasible. (2) To put the stomach at rest in advanced carcinoma of the stomach, phlegmonous gastritis, severe ulceration, or corrosion of the lining of the stomach.

Witzel's Method.—A 5-cm. transrectus incision is made just above the level of the navel; a loop of jejunum, 8 inches below its origin, brought out; a No. 12 French catheter introduced, and buried in the antimesenteric surface as in the Witzel gastrostomy. The bowel where the tube emerges is anchored to the anterior abdominal wall by sutures.

Coffey's method is a modification in which the serosa and the muscularis are divided, and the tube buried for 3 or 4 cm. between the muscularis and mucosa.

Maydl and Mayo-Robson operations, using sections of jejunum to form a tube to connect the bowel with the skin, are unnecessarily formidable.

Fig. 821.—The Billroth I partial gastrectomy modified by splitting the inferior edge of the divided duodenum to produce a large stoma in the end-to-end anastomosis.

Gastrorrhaphy (Gastropexy).—The ptosed stomach may be suspended by Beyea's operation (1903), the gastrophrenic and gastrohepatic ligaments supporting the stomach being shortened by rows of plicating sutures of fine silk or linen. The gastrohepatic ligament is so tenuous that only a limited support is obtained.

Coffey's hammock-operation consists in suspending the transverse colon and the greater curvature of the stomach by interrupted plicating sutures carried through the great omentum, and sewn to the peritoneum on a transverse line midway between the navel and the ensiform. If the liver is ptosed, it also is supported by purse-string sutures through the falciform ligament, and by quilt-sutures fastening the edges of the right and left lobes to the parietal peritoneum. It has the disadvantages of the abnormal support and the adhesions produced.

Rovsing's operation fixes the anterior wall of the stomach to the anterior abdominal wall by three rows of strong silk-sutures, holding the scarified anterior surface of the stomach against the anterior abdominal wall; the ends of the sutures being tied over a plate or pad placed over the abdominal wound. Operations that fix normally movable organs to the anterior abdominal wall are objectionable from a physiologic standpoint.

Gastrolysis consists in the liberation of the adherent stomach, either by a sharp knife, by scissors dissection, or by blunt separation.

Gastroplication (*Brandt's Operation*).—A number of interrupted or continuous sutures are introduced along parallel lines through the serous and muscular coats so as to produce transverse folds or plaits in the anterior gastric wall. Through an opening in the great omentum, correspond-

ing plaits or folds may be formed on the posterior wall of the stomach. Obviously the operation interferes with the normal peristaltic wave, and it has had a limited use.

Pylorotomy, Pyloroplasty (*Heineke-Mikulicz Operation*). –The pylorus is freely divided in the axis of the canal and united by sutures which convert the longitudinal into a transverse wound. The size of the new opening, of course, varies directly with the length of the incision through the pylorus.

Gastro-enterostomy.—(A) *Anterior or Wölfler Operation.*—(1) The abdomen is opened through a 10 cm. vertical upper right transrectus incision, and explored by the hand. (2) The ligament of Treitz and first portion of the jejunum are located by sweeping the hand from left to right across the root of the transverse mesocolon. (2) A loop of jejunum is located 40 to 50 cm. below its origin,

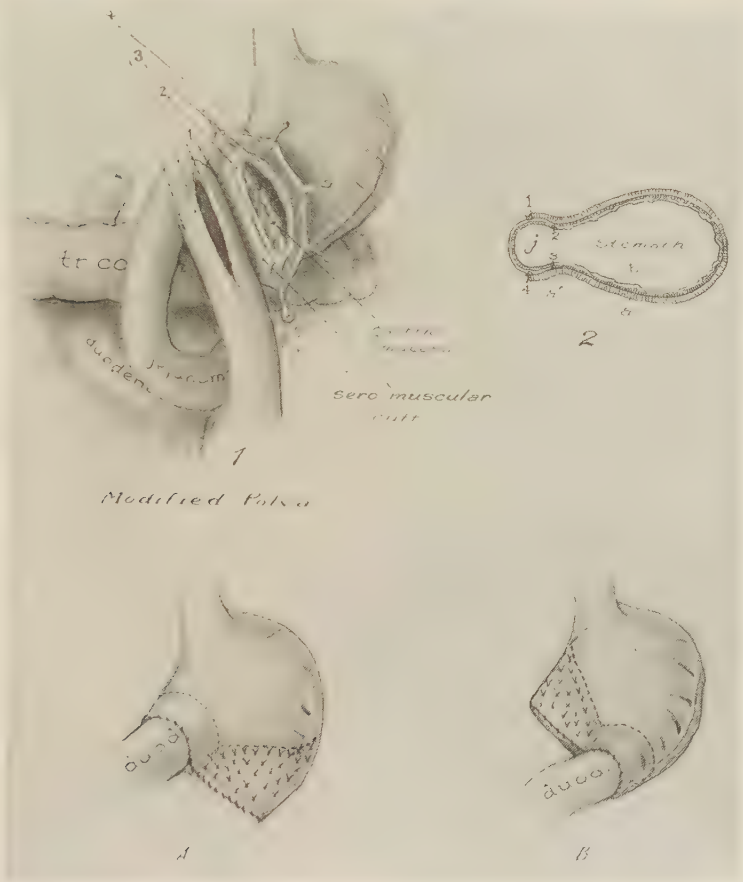


Fig. 822.—The Fränkel-Babcock telescopic anastomosis in partial gastrectomy, with resection of mucosa of the stomach.

brought in front of the colon, and apposed to the anterior wall of stomach near the greater curvature, 8 to 10 cm. proximal to the pylorus. On the stomach the bowel should run obliquely from above downward and from left to right (isoperistaltic). (4) Directly opposite the mesenteric attachment a line 6 cm. long is scratched on the jejunum, a corresponding scratch is made on the stomach indicating the position of the proposed stoma. (5) If leakage is feared during the suture, soft-rubber covered clamps are applied to the base of the loop of bowel and also to the fold of stomach that has been marked. (6) By a continuous seroserous suture of No. 0 chromic catgut the bowel and stomach are united 1 cm. distant from the scratch mark, for a length of 8 cms. (7) The stomach and intestine are opened along the lines marked, redundant mucous edges trimmed away, and the posterior mar-

gins of the openings united by No. 0 chromic catgut, using a continuous through-and-through suture in a straight (cambric) or curved intestinal needle. The suture is continued around the anterior margins of the opening slightly everting the mucous edges that bleeding vessels may better be seen.

Fig. 823.—Modified Billroth I gastrectomy: Partial closure of the gastric incision.

Fig. 824.—Modified Billroth I gastrectomy: Stoma placed at upper end of gastric incision.

With the completion of the through-and-through suture the ends are tied, the clamps loosened, and the bleeding vessels closed by interrupted sutures. (8) The posterior seroserous suture is now completed in front of the opening, also at a distance of 1 cm. and the ends tied. There should be no

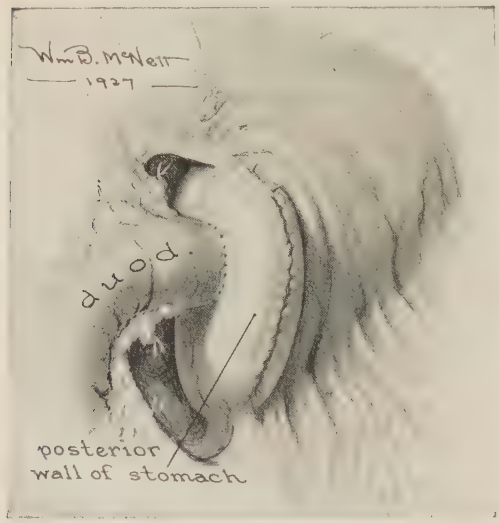


Fig. 825.—Kocher's partial gastrectomy with end-to-side anastomosis of duodenum.

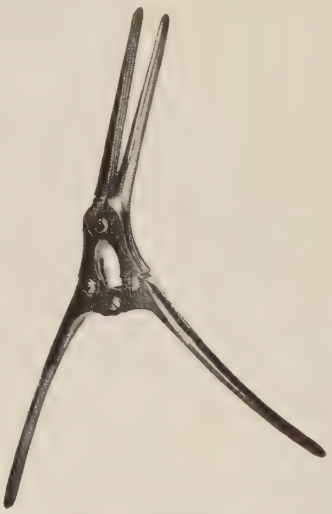


Fig. 826.—Payr's crushing forceps used in dividing the stomach or intestines.

torsion or acute angulation of the loops of intestine, and additional sutures may be necessary for support, or to alter the direction of the bowel where it joins or leaves the stomach.

Anterior gastro-enterostomy is used as a palliative operation in carcinoma of the pyloric end of the stomach and as a part of the operation of gastrectomy. Marginal ulcer and vicious circle

more frequently follow anterior than posterior gastro-enterostomy and an entero-entero anastomosis between the loops of the jejunum is often added to the operation.

Fig. 827.—Gastroplication (Brandt's operation) for gastrectasia: Suture introduced into anterior wall of the stomach.

(B) *Posterior Gastro-enterostomy (von Hacker's Operation).*—Using a short loop, is the preferred type of gastro-enterostomy. (1) Incision and preliminary abdominal exploration, as for anterior

Fig. 828.—Gastroplication: Suture tied.

gastro-enterostomy. (2) The stomach and transverse colon are lifted out of the wound making taut the transverse mesocolon which is divided for 7 cm. between vessels exposing the posterior wall of

the stomach. A fold of the stomach is pulled through the opening and the rest of the stomach and the transverse colon returned to the abdomen. The line of the gastric stoma is vertical and extends cephalad from a point close to the greater curvature for 6 cm. in line with the vertical part of lesser curvature of the stomach (Moynihan). (3) The edges of the opening in the transverse mesocolon are attached by fine interrupted sutures to the posterior wall of the stomach, 3 or 4 cm. distant from the line of the proposed stoma. (4) A loop of jejunum about 7 cm. from the ligament of Treitz is liberated, if necessary, from restraining peritoneal folds, the line of anastomosis marked directly opposite the mesenteric attachment and applied to the stomach so that the bowel runs from above downward (isoperistaltic). (4) The anastomosis is made with or without clamps precisely as for an anterior gastro-enterostomy. Occasionally a third row of sutures is added for better hemostasis or security. (5) The parts are returned within the abdomen and inspected to make sure that no angulation or twist of the bowel has been produced. The mortality of gastro-enterostomy is 2 per cent. or less. It is the safest and usually the preferred operation for chronic duodenal ulcer. It is less satisfactory for gastric ulcer for which many surgeons now prefer a partial gastrectomy. It may be combined with cautery destruction of the ulcer and suture (Balfour's operation). It favors the healing of peptic ulcers by affording better mechanical drainage (although the food may continue to leave the stomach through the pylorus) and by chemically neutralizing the erosive gastric contents by a reflux of the alkaline duodenal fluids into the stomach. The average reduction in the gastric acidity which is produced is 30 per cent. (Paterson).

(C) *Partial gastrectomy* is used for cancer and other tumors of the stomach, hour-glass contraction of the stomach, chronic gastric ulcer, and marginal ulcer.

1. *Billroth No. I.*—A resection of the stomach with end-to-end anastomosis is used when the end of the stomach and duodenum may be united without excessive tension. The danger of the "fatal angle," where the three lines of suture meet, disappeared when surgeons acquired the art of intestinal suture.

2. *Billroth No. II.*—A partial gastrectomy, with closure of the open end of the stomach and a separate anterior or posterior gastro-enterostomy, has been used when an end-to-end union of stomach and duodenum was not feasible.

3. *Reichel-Polya gastrectomy,* characterized by a union of the cut end of the stomach with the side of a loop of jejunum, is the simplest and quickest method for partial gastrectomy.

Technic of Partial Gastrectomy.—1. Right vertical upper rectus incision, 12 to 14 cm. long. 2. Exploration of the abdomen. 3. Ligation and division of blood-vessels of the stomach, namely: (a) Right gastric and gastroduodenal artery, gastrohepatic omentum, and left gastric artery. With division of the left gastric artery the stomach is mobilized and may be pulled forward and to the right. (b) The right gastro-epiploic artery, the gastrocolic omentum in sections (avoiding the posterior leaf containing the midcolic artery supplying the transverse colon), and the left gastro-epiploric artery near the line of proposed section of the stomach. 4. Division of the first part of the duodenum by cautery or knife between clamps. 5. Unless a Billroth No. I operation is to be done the end of the duodenum is closed by purse-string or other inverting suture. The stomach is turned to the left, divided along the Hartman, Mikulicz or Mayo line between clamps, and the cut end anastomosed by two or three rows of continuous No. 0 chromic catgut sutures to the side of the jejunum, as in gastro-enterostomy. If a retrocolic anastomosis is made the cut end of the stomach should be brought through and fastened to the edges of the opening in the transverse mesocolon.

The mortality of posterior gastro-enterostomy for ulcer is 3 per cent. or less; for cancer, 10 per cent. or less.

Midgastric or Coat Sleeve Resection of the Stomach.—An equatorial section of the stomach including a section of the lesser and greater curvature is removed with end-to-end closure. The operation has been used for hour-glass stomach, benign tumors, certain gastric ulcers, but may interfere with peristalsis, although less than after a V-shaped resection. The operation is considered inferior in results to partial gastrectomy.

Total gastrectomy has a very limited use, but has been employed for carcinoma of the stomach and linitis plastica and may be considered in rare forms of destructive inflammation of the stomach. The end of the esophagus should be united with great care to the side of a loop of jejunum, or to the end, or side (Finney) of the duodenum. After complete gastrectomy the jejunum dilates and the metabolic balance is preserved.

CHAPTER L

THE SMALL AND LARGE INTESTINE

General Considerations.—The *foregut*, which extends to the second part of the duodenum, prepares food; the *midgut*, from the second part of the duodenum to the end of transverse colon, absorbs food. Solids are absorbed in the small intestine, and 80 per cent. of all liquids in the ascending and transverse colon. "We eat with the jejunum and ileum and drink with the ascending and transverse colon" (W. Mayo). The *hindgut* consists of the descending colon and rectum, and is the storehouse for residue. Reverse currents (*currents of Bond*) found in the intestine, especially in the large bowel, return liquids to the ascending and transverse colon for absorption, and render high enemas unnecessary.

The small intestine varies in length from 5 to 11 meters (15 to 33 feet), with an average of about 22 feet. The metabolic balance continues after removal of two-thirds or less of the small intestine,

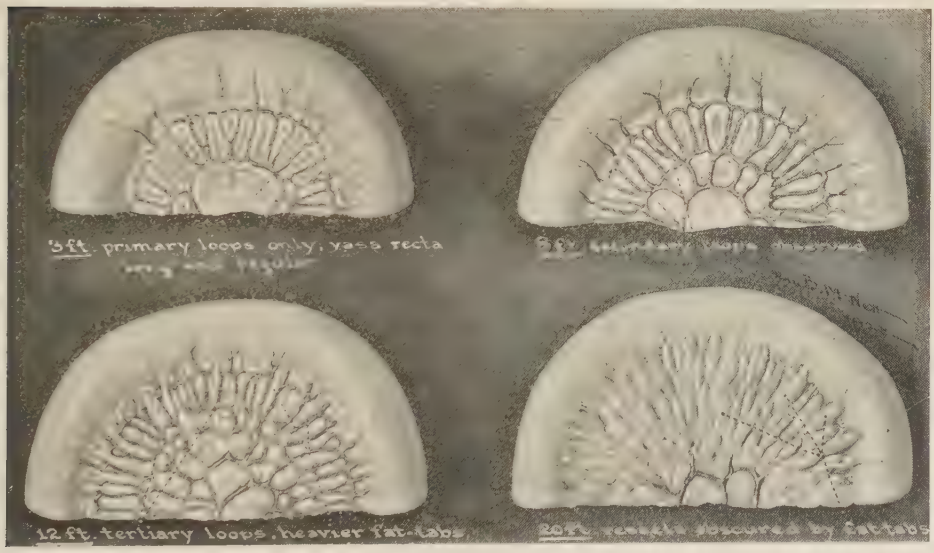


Fig. 829.—Intestinal localization (Monks): The walls of the small intestine become progressively thinner from above down. The single vascular loops or arcades in the mesentery develop secondary and then tertiary loops, and finally in the lower ileum are obscured by fat.

the ileum being less important than the jejunum. After more than 2.13 meters (7 feet) of the jejunum are removed, wasting and slow starvation follow. Life may continue, however, after the removal of 4 meters (12 feet) of the lower small intestine. After extensive resection, there is increased appetite, diarrhea, wasting, and decreased absorption of fat and nitrogenous food. Removal of the entire colon is well tolerated, but with more frequent and more liquid stools. The loss in liquids necessitates an increased intake of water.

Under normal conditions seven to nine hours are required for the stomach and small intestine to become empty after a meal. Intestinal distention is increased (Margzloff) in patients given physostigmin (eserin) and strychnin before an operation.

Intestinal Gases.—*Meteorism* results from: (1) Decomposition of intestinal contents; (2) diffusion of blood-gases into the intestinal lumen through the mucosa; (3) the passage of atmospheric air from the stomach into the intestine.

Gases are removed by absorption into the blood, the absorption of atmospheric air being slow. In general peritonitis, atmospheric air is an important source of the gas distention.

In order of rapidity of absorption, carbon dioxid, hydrogen sulphid, oxygen, hydrogen, methane (CH_4), and nitrogen are taken up by the blood. The first two are absorbed very rapidly, hydrogen sulphid being toxic. Postoperative gases found in the intestine consist, according to McIver, chiefly of: Nitrogen, about 80 or 85 per cent.; carbon dioxid, about 5 or 10 per cent.; oxygen, 1 or 2 per cent.; methane, 2 to 10 per cent.; hydrogen, 1 or 2 per cent., except when milk is taken, when it may reach 25 to 35 per cent. Hydrogen sulphid usually is present in traces only. Obviously milk should not be used immediately before or after operations involving the peritoneum.

Intestinal localization is determined by:

1. *Thickness of Bowel.*—The higher coils are thicker and have ridges from the valvulæ conniventes, while lower coils are thinner, paler, and less vascular.

2. *Character of Arrangement of Blood-vessels in Mesentery* (Monks).—(a) *Upper 2 meters*—the vessels of the jejunum form single arcades, average 6 cm. in length, and are without large branches. (b) *Second 2 meters*—secondary arcades appear with smaller branches. (c) *Beyond 4 meters*—the arcades consist of three superimposed loops with an increase in mesenteric fat. (d) *Beyond 6 or 7 meters*, or in the lower ileum, there is an irregular network of vessels obscured by fat and without distinct arcades.

3. *The Direction of the Attachment of the Mesentery to the Spinal Column.*—By pulling a loop of bowel out of the abdominal incision, and slipping the hand along the spinal attachment of the mesentery, the direction of the bowel may be ascertained.

The colon has longitudinal bands; the ascending colon, no omentum; the transverse colon, the large omentum; while the descending colon has no omentum or mesentery. The sigmoid loop has a small lumen, and very thick walls.

Congenital Anomalies.—A. **Congenital stenosis and atresia** is most common in: (1) The rectum and anus; (2) the lower ileum, especially in the region of attachment of vitello-intestinal duct; (3) the duodenum, usually above the papilla of Vater, or with involvement of the papillæ and distention of the biliary and hepatic ducts. (4) Multiple areas of stenosis may be present. The colon is seldom involved, except by a congenital kink of the sigmoid flexure.

B. **Anomalies in position** chiefly involve the colon, and include: (1) Failure of rotation of the colon; (2) situs inversus with the cecum and appendix on the left and the sigmoid upon the right side of the abdomen; (3) the colon upon the right or left side, or lying behind the small intestine. The cecum varies greatly in size and position, and marked variations occur in the length and position of the transverse colon and sigmoid. While the position may confuse the diagnostician or operator, as a rule no treatment is required.

Symptoms from congenital intestinal obstruction resemble those of acquired obstruction, with vomiting, obstipation, and abdominal distention.

Treatment.—Obstructive conditions are to be treated by liberating kinks or adhesions, an anastomotic operation, intestinal elimination, enterostomy, or the formation of an artificial anus. Unfortunately, babies bear enterostomy and other intestinal operations badly (death usually following), except the liberation of a kink of the sigmoid, or the opening of the simpler forms of imperforate anus.

Congenital Obstruction of the Duodenum.—*Etiology:* In embryonic life the anterior mesentery extends caudad, as the mesogastrium, as far as the proximal third of the duodenum. The caudad edge of the anterior mesogastrium may persist, and bind down and constrict the duodenum at birth.

Symptoms.—Regurgitation of food and bile, beginning immediately or within

a few days after birth. It differs from congenital pyloric stenosis in the absence of palpable tumor, and in that the symptoms are not delayed until the seventh or ninth day (Harris).

Treatment.—Operation, and division or liberation of the constricting bands.

Duodenal diverticulosis is found in 2 out of every 12 cadavers (J. C. B. Grant) or in one and two-tenths per cent. of the patients subjected to roentgenologic examination (Case). The ratio of diverticulitis to diverticulosis is 1 : 5.

Varieties: (1) Diverticula on anterior peritoneal surface of duodenum; (2) diverticula embedded in pancreas; (3) diverticula behind pancreas or in retroperitoneal space (MacLean).

Symptoms.—Indigestion, gaseous eructations, nausea, vomiting, loss of weight, vertigo, constipation, epigastric pain. The symptoms are not characteristic, and simulate a gastric or extragastric lesion.

Diagnosis by roentgenologic study.

Treatment.—Excision and suture, which is easy with the anterior peritonealized type, but is difficult if the diverticulum lies in or behind the head of the pancreas. In operating, the peritoneum is divided along the right border of duodenum, exposing the posterior surface, the third and fourth parts of the duodenum and the head of pancreas. By raising the mesocolon and great omentum, the duodenum is accessible below the attachment of transverse mesocolon. The posterior parietal peritoneum is incised, the right colic artery avoided, and the superior mesenteric vessels drawn to the left, exposing the posterior surface of the third and fourth parts of duodenum and the head of pancreas.

Meckel's diverticulum is the result of an incomplete obliteration of the vitellointestinal duct. It is found in 2 per cent. of the abdomens examined as a blind pouch or tube projecting from the lower ileum, $\frac{1}{3}$ to $1\frac{1}{2}$ meters (12 to 52 inches) above the ileocecal valve. Usually it is attached to the antimesenteric border of the bowel, the tip being free or (rarely) united to the umbilicus. The diverticulum is cylindric, cone-shaped, or club-shaped, and a valve may exist at its junction with the intestine.

It is subject to: (1) *Inflammation* (*Meckel's diverticulitis*), catarrh, ulceration, perforation or gangrene, similar to the appendix; (2) *strangulation* as in a hernial sac, forming a type of Littré's hernia; (3) *twists* or *attachments*, angulating or obstructing the intestine; (4) *ulceration*, *perforation*, or *obstruction;* (5) *contained foreign bodies.*

Diagnosis.—Diverticulitis of Meckel's diverticulum is to be considered when an inflammatory intra-abdominal mass is adherent to or is in close relation with the umbilicus, associated with symptoms suggesting appendicitis. When the diverticulum remains attached to the navel, the intestine may twist about it and become strangulated.

Treatment for inflammation or obstruction is the operative removal of the diverticulum, with closure of the intestinal opening as in appendicitis. Adherent or obstructed intestine should be liberated or, if gangrenous, resected or isolated with an entero-anastomosis, or enterostomy.

Idiopathic Dilatation and Hypertrophy of the Colon.—Congenital Idiopathic Dilatation of the Colon, Megacolon, Hirschsprung's Disease (1886).—

Great enlargement of the colon, not due to obstruction, is found in infancy, childhood, and after middle life. In children the circumference of the colon may be increased to 35 cm., in adults to 50 cm., with a proportionate increase in capacity. Usually the colon is lengthened and the walls are two or three times the normal thickness. In childhood the pelvic colon and rectum are chiefly affected, in adults the cecum, ascending, and transverse colon. Fecal impaction with the formation of a firm mass, the size of an orange or adult head, is common. Peritoneal inflammation is rare.

Etiology.—(1) Male sex. (2) Age. The dilatation often develops in the first year of life and is usually recognized before the age of ten. The senile type occurs after the age of forty. (3) Congenital malformation. (4) Elongation of the sigmoid and mesosigmoid with possible angulation. (5) Constipation, procrastination, and neglect to form regular habits of evacuation, so common in childhood. (6) Intestinal atony.

Fig. 830.—Hirschsprung's disease in a boy of six years.

Symptoms.—(1) *Constipation* is usually marked. Incomplete evacuations of the bowel may occur every one to seven days or at intervals of one to three months. (2) *Diarrhea* may alternate with constipation and give temporary relief. (3) *Abdominal distention* and pressure symptoms are usual, including visible and audible peristalsis, greatly enlarged abdomen, short contracted thorax, everted costal margins, elevation of the diaphragm, and dyspnea on exertion. Varicosities and edema of the legs result from venous obstruction. (4) *Wasting* and loss of appetite is common, vomiting is not unusual.

Terminal Complications.—Toxemia, convulsions, and tetany occur in childhood, neurasthenia and melancholia in adults. Death occurs from pulmonary and renal complications, or a stercoral ulcer with perforation, and peritonitis.

Diagnosis.—A large firm mass that is doughy or dents slightly on pressure, in the lower abdomen of a child, with the history of chronic constipation or intestinal obstruction, usually is due to Hirschsprung's disease. The character of the mass may be proved by examination with the finger in the rectum, the proctoscope, or by films made after a barium meal or enema.

Prognosis.—Hirschsprung's disease may be fatal within a few weeks or continue for years. Death occurs from pulmonary complications, toxemia, or

perforation in two-thirds of the untreated patients. The mortality after operation is 20 per cent. or more.

Treatment.—(a) *Evacuation of Colon.*—This may be difficult and require several days or weeks. Laxatives are often useless. Enemas containing oil, glycerin, milk, and molasses, or peroxide of hydrogen (10 per cent.) may be used twice daily, or repeated attempts made to empty the bowel by colonic lavage. Abdominal massage and the removal of low-lying masses by a finger or scoop in the rectum, are useful. An abdominal incision, without opening the colon, may be necessary to break up a large fecalith. If other measures fail an appendicostomy, cecostomy, or colostomy may be used, with daily lavage through the new opening. During this period, a diet of nourishing food leaving little residue should be used.

(b) *Maintenance of Evacuation.*—After the colon has been emptied, reaccumulation should be prevented by daily colonic irrigations or enemas, the use of liquid petrolatum, strychnin, and eserin by mouth, and abdominal massage, vibration, or electricity to the colon. The diet should now be rich in cellulose.

(c) *Operation.*—In extreme and resistant forms, operative elimination of the diseased portion of bowel as by an ileosigmoidostomy, or partial or complete colectomy, preferably by Mikulicz's method, may be considered. These operations have a high mortality, especially in children, and they should not be undertaken until a cecostomy has been tried. The mortality of colectomy is greatly reduced by a preceding colostomy or short-circuiting operation.

Traumatic Injury.—The intestine may be ruptured, lacerated, or torn from its mesentery. Frequently the tear is at the junction of the duodenum and jejunum, or of the ileum in the ileocecal region.

Etiology.—The injury follows a violent blow or compression from the fist, a kick; run-over accident by wagon, automobile, or train; or a crush between cars, or in an elevator. The rupture results from compression of the intestine against the body of the underlying vertebra, the promontory of the sacrum, or pelvic bone. Rupture has even followed violent contractions of the muscles of the abdominal wall, especially in aged persons with intestinal distention. Perforating and penetrating wounds occur from stabs, bullets, and falls upon broken bottles or other sharp objects. Not infrequently the intestine has been dragged through the cervix, and torn from its mesentery in the emptying of the uterus for miscarriage or abortion. As a workman's prank, the bowel has been ruptured by the high air-pressure from a pneumatic nozzle held near the anus. Absolute contact or introduction of the nozzle is unnecessary, and the injury usually is fatal. The rectum or pelvic colon has been perforated many times by physicians and others in the introduction of proctoscopes, rectal bougies, or stiff tubes. Rupture of the colon, or the opening of a recently closed appendiceal stump, has followed the use of large enemas. Secondary constriction and obstruction may be due to contusion, or the strangulation of the gut in a hernial sac.

Symptoms include shock, diffuse abdominal rigidity, evidence of pneumo- and hemo-peritoneum, severe abdominal pain, vomiting if food or liquid is given, and increased pain and ineffective evacuation when enemas are tried. Secondary peritonitis rapidly follows, with thoracic respiration, increasing pulse-

rate, obliteration of the liver dulness, and dependent shifting dulness from intraperitoneal fluid and exudate.

Prognosis.—Fifty per cent. of the patients recover from operation performed during the first twenty-four hours; 25 per cent. after the first twenty-four hours, the mortality increasing with delay.

Punctured and gunshot wounds are occasionally spontaneously occluded by the protruding mucosa, with recovery or local abscess formation, as was noted in the Boer War. The chance for recovery is enhanced by an empty intestine, or by starvation before and after the injury.

Treatment.—Immediate operation is, in any case, indicated by a penetrating wound, or by board-like rigidity of the abdominal wall after injury. Intense shock, not due to hemorrhage, should be treated before the operation is attempted. A vertical or transverse incision is made over the site of injury, the wound tract and abdominal cavity explored, and the entire length of intestine reviewed. Perforations should be closed by suture and devitalized and detached portions of intestine treated by resection, enterostomy, or artificial anus. No liquid food or enema should be given before the operation and, after the operation, the pressure on the suture-line reduced by the constant use of a rectal tube for a week or more.

Ileus (Intestinal Obstruction).—The interruption of fecal current in the intestine.

Varieties.—(1) Reflex ileus; (2) mechanical ileus; (3) inflammatory ileus; (4) dynamic, spasmodic, or spastic; (5) adynamic, paralytic, or inhibitory.

Etiology.—A. *Neurogenic:* 1. Afferent system, from cord injury or disease, as in fracture of the spine, in tabes or myelitis.

2. Reflex: (a) renal (calculi); (b) ovarian (trauma); (c) testicular (blow); (d) biliary (stone); (e) tumors (twisted pedicle); (f) thoracic, as from pleurisy or pneumonia. The vagus nerve and Auerbach's plexus stimulate peristalsis, while the sympathetic vasomotor nerves inhibit peristalsis.

B. *Vascular:* Embolism or thrombosis of the mesenteric vessels.

C. *Toxic*—poisons taken into or formed in the body: (1) Drugs, as lead, tyrotoxicon; (2) bacterial (the inflammatory ileus of local or general peritonitis).

D. *Mechanical Obstruction:* 1. From without bowel, as: (a) Bands; (b) adhesions; (c) tumor; (d) strangulated hernia, internal or external.

2. From within bowel, as: (a) Foreign body; (b) impacted feces; (c) gallstones; (d) parasites (ascaris); (e) enteroliths (coproliths, hair-balls).

3. From wall of bowel, as: (a) Tumors, especially cancer; sarcomas and endotheliom as rarely obstruct; (b) stricture (healed ulcer, syphilis); (c) intussusception.

4. From intra-abdominal tension, as after reduction of very large hernia or extensive resection of anterior abdominal wall with closure.

Metabolic changes are more marked with the higher forms of obstruction. There is toxemia with marked destruction of tissue-protein and alkalinosis. Nitrogen excretion is increased, with an excess of non-protein nitrogen and urea in the blood. Chlorids are reduced in the urine and blood. Alkalinosis, shown by high plasma carbon-dioxid combining power, occurs from loss of chlorids through vomiting (Whipple, Haden, and Orr, 1927).

Etiology as to Age, Sex, Heredity.—A. *Age:* 1. Infancy—congenital strictures, Meckel's diverticulum, band connecting with navel. Intussusception (50 per cent. occur below one year of age).

2. Middle life—strangulated hernia, adhesions, annular carcinoma.

3. Old age—(a) volvulus, (b) cancer.

B. *Sex.*—Males: Volvulus is especially common. Intussusception occurs in two men to one woman. In women, obstruction from the pressure of tumors outside the bowel is more common than in men.

Symptoms.—1. *Vomiting:* (a) Contents of stomach; (b) bile; (c) intestinal contents (*stercoraceous vomiting*).

2. *Abdominal Colic.*—Tormina center around the navel, and are twisting, cutting, griping: (a) In complete obstruction there is constant pain with exacerbations; (b) in incomplete obstruction there are remissions. If gangrene occurs there is temporary cessation of vomiting and pain.

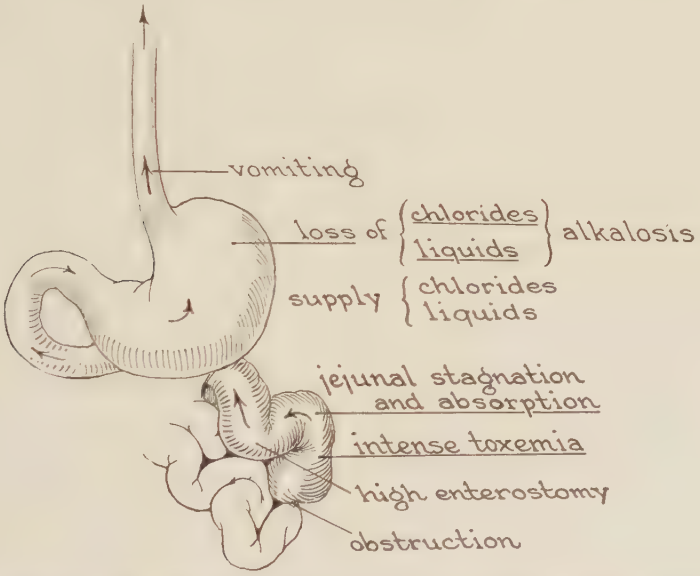


Fig. 831.—Results of high intestinal obstruction and the advantages of a high enterostomy to save the life of the patient.

3. *Meteorism.*—Gaseous distention of the intestine, without abdominal rigidity except from associated peritoneal irritation. Peristalsis may be increased or reduced.

4. *Obstipation.*—Early, the lower bowel may empty or a false diarrhea of blood and mucus with tenesmus develop, especially in intussusception, cancer, and mesenteric thrombosis. The bowel above the obstruction is distended by gas and fecal material, the bowel below is collapsed and empty. If the condition is chronic, the bowel becomes thickened and hypertrophic, with excessive peristaltic movements above the obstruction. The temperature is normal or subnormal until peritonitis or an abscess develops.

5. *Alkalinosis.*—Fall in blood and urinary chlorids.

At Seat of Obstruction: If circulation is interfered with, changes in gut occur: 1. Lining *epithelium desquamates.*

2. *Bacteria penetrate the wall* of the bowel.

3. *Exudation* of (a) serum, (b) leukocytes, and (c) erythrocytes, occurs from both serous and mucous surfaces.

4. *Peritoneal surface becomes red*, purple, black, finally gray with yellowish or grayish plastic adherent exudate, the shiny surface being lost.

Consistency: Thick, swollen, at first elastic and resilient, later inelastic.

Gangrene, shown by the black or grayish color of the intestine; *consistency*—like wet paper or chamois skin and absence of resiliency; *absence of peristalsis*, *absence of circulation*, and *offensive odor.*

Viability of intestine is determined by releasing and constriction, and noting: (1) If the color improves under warm packs wet with saline solution; (2) if the peritoneal coat is still shiny; (3) if the feel of the intestine is elastic and resilient; (4) if peristalsis returns; (5) if bleeding persists after scratching the gut; (6) if there is no offensive odor. When a section of the bowel is dead, peritonitis is always associated.

High Obstruction.—The symptoms are acute and the condition especially dangerous, with very rapid poisoning and death, often in a few hours, from *jejunal toxemia.*

Low Obstruction. A gradual accumulation of fecal material occurs, and may continue four to twelve weeks with a low toxemia if there is no associated peritonitis.

Intestinal alkalinosis (*alkalosis*) is characterized by fall in plasma chlorids (hypochloridemia) to 300 to 350 mg. (normally 560 to 650 mg. to 100 c.c.), a rise in blood-urea and urea-nitrogen (normal 12 to 18 mg. to 100 c.c.), fall in urinary chlorids, a normal or elevated plasma carbon-dioxid combining-power (normally 50 to 65 volumes per cent.). The urine is scanty, often contains casts and red and white cells. The loss or deficiency of hydrochloric acid from the gastric secretion is an important factor. The chlorids protect the body against toxemia by combining with split proteids.

Varieties.—(a) *Preoperative*, from high intestinal obstruction. (b) *Therapeutic*, from overuse of alkalies in the Sippy or other treatment. (c) *Postoperative*, with jejunal toxemia or jejunal ileus.

Symptoms.—Nervous irritability with numbness, tingling of extremities, muscular twitching, tetany, prostration, and often delirium. Profuse vomiting of turbid, offensive, yellowish fluid of the upper intestinal type, which is persistent, and not relieved by lavage as in atonic dilatation. Abdominal distention is usually absent. There is dehydration, flushing of the cheeks, fall in blood-pressure, rise in hemoglobin.

Treatment.—The indications are to supply chlorids, relieve dehydration and ileus: (1) *Intravenous infusion* with 500 c.c. of 10 per cent. glucose in decinormal saline solution; 1 gm. of sodium chlorid per kilo of body weight may be given; (2) *continuous hypodermoclysis* with saline solution 300 to 600 c.c. daily; (3) *hydrochloric acid*, salt, and ammonium chlorid by stomach; salt and ammonium chlorid by bowel; alternating lavage and aspiration by a Jutte duodenal tube, introduced through the nose or mouth and left in place for hours or days; (4)

in jejunal toxemia or ileus, a *high enterostomy* is especially important and often life-saving.

Acute dilatation of the duodenum (*acute gastromesenteric ileus*) follows operation upon the stomach, appendix, or other intra-abdominal organ. There is repeated vomiting of gastric and duodenal contents, with distention of the upper abdomen, alkalinosis, prostration, and collapse.

Treatment.—(1) Peroral duodenal-tube drainage and lavage, or the continued use of the Jutte tube through the nose; (2) high enterostomy; (3) treatment of alkalosis and dehydration by fluids, chlorids, and glucose.

Chronic Dilatation of the Duodenum.—Chronic duodenal dilatation occurs from: (1) *Division* or *occlusion* of the pylorus or upper duodenum, as after a Billroth II gastrectomy; (2) *compression of the duodenum* under the superior mesenteric or the right or midcolic artery, by a distended or ptosed transverse colon; (3) *compression by adhesions*, by neoplasm, or by tuberculous or other enlarged glands along the superior mesenteric artery. The adhesions or bands may involve the terminal duodenum or proximal jejunum; (4) *hernia in the jejunal fossa;* (5) *reflex atony and distention* from disease of the lower intestine; (6) *angulation* from ptosis of stomach and upper duodenum. Bloodgood describes an obstruction due to pressure of a giant cecum.

Symptoms.—Severe headache, attacks of epigastric oppression and pain, with vomiting of gastric contents and bile, heaviness and fulness in the right abdomen that may be mistaken for appendicitis, with occasional relief on assuming the prone position. Duodenal distention and hyperperistalsis, as shown by Roentgen examination after a barium meal.

Treatment.—(1) The wearing of a *supporting belt* or corset for ptosis, with duodenal-tube drainage and lavage; (2) *operative* relief from local pressure by glands, adhesions, or bands. If the obstruction cannot otherwise be relieved, *duodenojejunostomy* is advisable. The transverse colon being raised, an opening about 5 cm. in length is made over the distended duodenum through the transverse mesocolon, as in a posterior gastro-enterostomy. Resection of a large or distended right colon may be considered in a small percentage of cases. Gastro-enterostomy should not be done, as it leads to vicious circle.

Foreign Bodies in the Intestine.—1. *Swallowed:* (a) Children—toys, coins, stones, etc. (b) Lunatics—knives, forks, coins, spectacles, etc. (c) Exhibitionists—glass, nails, chains, knives, pins, etc. (d) Hysterical—hair-balls (*trichobezoars*). (e) Elderly—dental plates or bridges. (f) Surgical accidents—intubation tubes, parts of instruments. (g) Food residue—seeds, skins, shells, nuts (*phytobezoars*).

2. *Parasitic.*—Round-worms in ball form.

3. *Gall-stones* enter by ulceration, and may obstruct the intestine if over 2 or 3 cm. in diameter.

4. *Enteroliths* (stones formed in intestines) include: (a) Phosphatic stones—from chronic catarrh. (b) Alvinoliths—from calcareous salts, and oatmeal or other cellulose débris. (c) Medicaments, concretions of magnesia, bismuth, barium, salol. (d) Coproliths—fecal concretions.

5. *From Abdominal Cavity.*—Gauze sponges and metallic instruments usually ulcerate into intestines; sea-sponges rarely. Murphy buttons or

other appliances for anastomosis may cause ulceration, perforation, or obstruction.

6. *From Rectum, Vagina, Bladder.*—Foreign bodies, pessaries, calculi.

Symptoms are: (1) *Digestive* (dyspeptic); (2) *obstructive* (ileus); (3) *ulcerative* or *perforative* (abscess; local or diffuse peritonitis).

Diagnosis is made by the history, the roentgenogram, by palpation, and rectal examination. A fecal calculus (coprolith) may reach an enormous size.

Treatment.—For rough, sharp, or pointed articles, not too large to be passed: 1. *Vienna treatment*—(a) laxatives are avoided and an excess of potatoes, bread, and vegetables fed to surround and encase the foreign body or, better, (b) quantities of picked *absorbent cotton* diffused through milk or ice-cream are given. The cotton fibers wrap around sharp and jagged objects.

2. *Operative.*—If a foreign body produces intestinal obstruction, ulceration, or perforation, an enterostomy with removal of the foreign body and suture should be done. From the sigmoid and pelvic colon the body may be removed *per anum* by the finger or proctoscope. A broken glass bottle or other sharp object may first be encased in plaster-of-Paris cream and the object removed after the plaster has hardened about it.

Fig. 832.—Gall-stone, 3.1 x 3.5 cm. in diameter, removed by enterostomy from the jejunum. Patient, a woman aged sixty-four, had attacks of biliary colic for twelve years. Acute obstruction for four days with vomiting of intestinal contents. Recovery.

Intussusception is the passage of one portion of intestine into another (John Hunter). It is the chief cause of acute mechanical intestinal obstruction under five years of age; 50 to 75 per cent. occurring under one year.

Varieties.—(1) *Ileocecal*—80 per cent. have the ileocecal valve at the head of the mass. (2) *Ileocolic*—20 to 30 per cent. occur through the ileocecal valve. (3) *Colic* involves the colon only. (4) *Enteric* are usually agonic or postmortem, being double, multiple, or compound. In the small bowel the jejunum is involved four times as frequently as the ileum. (5) *Retrograde* or *ascending*—rare except in agonic form. (6) *Acute* or *chronic*. (7) *Postmortem* or *agonic intussusception* occurs in the death agony. They are always multiple, are without swelling; injection of vessels or adhesions, and usually are enteric or of the small intestine. Intussusception may be double, multiple, compound; acute, subacute, chronic.

Pathology.—The intussusception consists of an *entering layer*, *returning layer*, *ensheathing layer;* a *neck*, *body*, and *head* or apex.

Intussusceptum is the part that telescopes. *Intussuscipiens* is the part of intestine that receives the intussusceptum.

The mass is always curved toward the mesenteric attachment. Adhesions form between the serous surfaces. The mucous surface exfoliates, and the entire intussusceptum may ulcerate, become gangrenous, detached, and even be passed *per anum* with recovery (*rare*).

Etiology.—(1) *Male sex.* (2) *Age:* Seventy-five per cent. of the acute type occur in infancy and childhood. Fifty per cent. of the chronic type occur between the ages of twenty and forty. (3) *Enteritis* with associated increase in peristalsis. (4) *Hypertrophied Peyer's* patch. (5) *Prolapse of ileum* through the ileocecal valve. (6) *Polypoid* or *other tumor*, or an invaginated Meckel's diverticulum or appendix producing traction when caught by peristaltic waves.

Symptoms.—*Clinical Picture:* A plump, healthy infant draws up the legs, cries violently with spasm, vomits early, and develops bloody dysentery, while examination shows a cylindric mass in the abdomen.

The cardinal symptoms are those of ileus, with tormina and tenesmus, a sausage-shaped mass, and repeated small, mucous, blood-stained stools. The vomiting is not quite as severe or as continuous, nor the tympany as marked

Fig. 833. Intussusception in cross-section showing the situation of Maunsell's incision for resection of the intussusceptum.

in early stages, as with other forms of obstruction. Rarely the apex of the mass can be felt by a finger in the rectum.

Diagnosis.—A small child or infant is found with shock, subnormal temperature, and symptoms of ileus. The vomiting occurs, usually only at the onset, and is rarely stercoraceous. There are frequent mucous and blood-stained stools, with tenesmus, and a palpable mass or tumor is felt in 70 per cent. Later, symptoms of peritonitis develop.

Prognosis.—In the *acute form* the mortality is 70 per cent., and the patient usually dies within one week. In the *subacute form* the mortality is 30 per cent., and the patient usually lives from one week to one month. In the *chronic form* the mortality is 20 per cent., and the patient (usually an adult) lives over one month.

In acute intussusception the prognosis is bad, for without operation over 90 per cent. die, while with operation 70 per cent. die. With operation in the first twenty-four hours only 20 per cent. die.

Treatment.—If recognized early (first few hours), reduction should be attempted by: (a) *Jolting* (the child hanging upside down, suspended over the surgeon's shoulders by the legs); (b) *distention of intestine* by enema—the bag should not be over 1 meter (3 or $3\frac{1}{2}$ feet) above the rectum. In the first twenty-four hours hydrostatic pressure will cause reduction in 60 per cent. It usually fails after the second or third day.

Operative treatment should not be delayed if reduction is not immediately obtained. If the bowel is found to be viable, the intussusception is reduced by squeezing from the distal to the proximal end, *never by pulling the ends apart.*

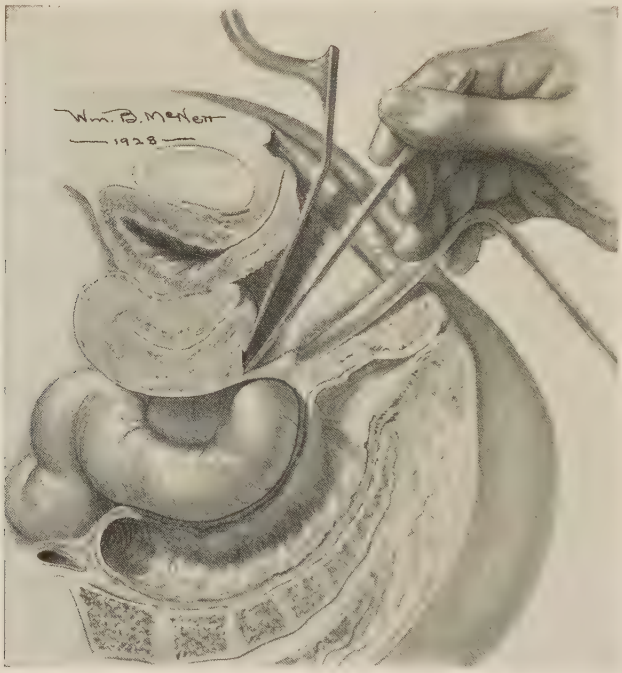


Fig. 834.—Vaginal enterostomy: Vaginal incision behind the cervix. For acute intestinal obstruction in the pelvis of a woman with peritonitis or adhesion a vaginal enterostomy rarely may be preferable to an abdominal operation.

Suture of the bowel may be desirable to prevent recurrence. If gangrene is present, the bowel should be resected and anastomosed. In older patients the gangrenous loop may be brought outside, and an artificial anus formed. An artificial anus should be avoided in infants, as it usually is fatal. Resection is accomplished by end-to-end suture or Maunsel's method.

Recurrences after operation for intussusception are rare, occurring in only 1 or 2 per cent.

Volvulus.—Obstruction from twisting of the bowel occurs: (1) About the long axis of the gut; (2) at right angles to the axis of the intestine, or about the mesenteric axis, forming a kink; (3) about the mesenteric root; (4) about an

adhesion or another loop of bowel. It usually involves the sigmoid (50 per cent.), sometimes the cecum and ascending colon, occasionally the small bowel. It is three times as frequent in the sigmoid as in the right colon, except in Baltic countries. It forms 12 per cent. of the cases of intestinal occlusion.

Pathology.—A twist of over 180 degrees causes occlusion of the lumen, with rapid formation of gas within the loop, great distention, and increasing toxemia from fermentation. Later the blood-supply is cut off, with strangulation, hemorrhage, and gangrene or, occasionally, perforation or rupture of the bowel from the gas-distention, the outer coat giving way first. Peritonitis is common.

Etiology.—Volvulus occurs in three men to one woman, usually between the ages of forty and seventy. The sigmoid loop is especially involved in elderly men, the small intestines in persons under forty or in children. It is rare under thirty, but has been reported in a child of nineteen days. A long mesentery

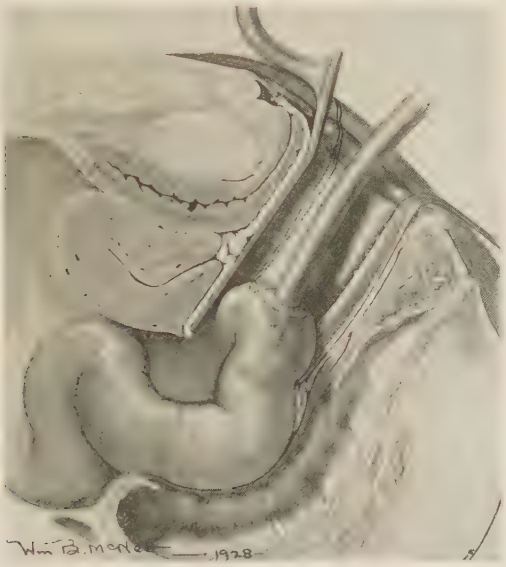


Fig. 835.—Vaginal enterostomy: A tube is fastened by interrupted purse-string sutures into the distended loop of intestine. The adjacent pelvis is protected by gauze.

predisposes. Volvulus follows purgation, adhesions from former abdominal operations, intestinal kinks, a heavy vegetable diet, tumors, mesenteric cysts, foreign bodies, or occasionally pregnancy.

Symptoms.—Acute, subacute, and chronic forms occur. The usual acute attack is characterized by violent peristalsis, and: (1) Signs of ileus; the pain is colicky, appears early, and is very severe; (2) large tympanic mass in abdomen, anterior and medial; (3) embarrassed respiration from pressure; (4) vomiting which is late, and rarely stercoraceous; (5) signs of peritonitis which appear early, with great distention, tenderness, and rigidity. In the chronic form there are intermittent obstructive attacks over a period of several years; varying widely in intensity, duration, and frequency; with a tendency to disappear spontaneously. The abdominal pain is indefinite, colicky, and nagging, often referred to the back and accompanied by constipation.

Prognosis.—If unrelieved, the average duration of an acute case is about one week. Death occurs from asphyxia, sepsis, or peritonitis, but usually results from toxemia before perforation occurs.

Treatment.—Immediate operation. The loop of bowel is untwisted, with suture, elimination, or resection. A colostomy or Mikulicz's operation is preferable if the gut is gangrenous.

Intestinal Strictures.—**Etiology:** 1. *Congenital strictures* are rare, and involve the lower ileum, from excessive obliteration of vitelline duct; or the pylorus, duodenum, jejunum, or colon.

2. *Ulceration:* Tuberculosis is a common cause of stricture of the small intestine, as the ulcers have a long axis across that of the bowel. *Syphilitic*

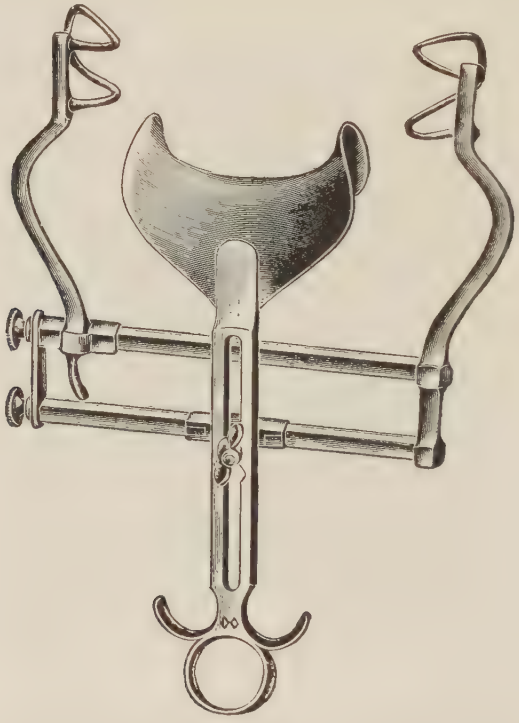


Fig. 836.—Balfour's self-retaining abdominal retractor.

strictures are common in the rectum, but rare in other parts of the gut. Dysenteric ulcers cause 85 per cent. of the strictures of the colon not due to cancer. Typhoidal ulcers have their long axis parallel with the bowel, and rarely cause stricture.

3. After *strangulated hernia* from secondary contraction, fibrosis, and atrophy; the obstruction developing from a month to years later, usually in the ileum.

4. *Injury* from a blow, the use of the Murphy button, suture, or from foreign bodies.

5. *Diverticulitis* and *peridiverticulitis* chiefly affect the pelvic colon, forming a dense, contracting, fibrous mass.

6. *Carcinoma*, with annular or tubular constriction or a projecting mass occluding the lumen, is the common cause of intestinal obstruction after middle life. It chiefly affects the rectum, sigmoid, and colon. The cancer may also obstruct by producing angulation, volvulus, or intussusception. Polyps, papillomas, and other benign tumors rather rarely cause obstruction. Sarcoma rarely occludes the lumen of the bowel.

Symptoms are progressive or of sudden onset, and are those of a chronic or acute ileus.

Chronic intestinal obstruction is characterized by: (a) *Pain*, dyspepsia, and colic increased by food and by laxatives; (b) *vomiting* at times; (c) *obstipation*, or at times mucous or bloody stools; (d) *tympany*—increased peristalsis, with intestinal dilatation or hypertrophy; (e) *wasting asthenia, cachexia*—the temperature is normal or subnormal, unless the condition is complicated by inflammation.

Diagnosis is based on the history, physical findings, rectal examination, and the study of roentgenograms. In the small bowel, 60 per cent. of the strictures are caused by previous inflammations, 40 per cent. by tumors. In the colon, 80 per cent. are due to malignant tumors.

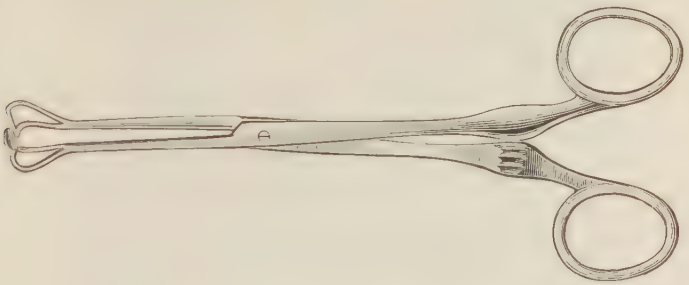


Fig. 837.—Babcock's viscera forceps.

Treatment.—1. A bland diet without indigestible residue is desirable. Laxatives are to be avoided or used cautiously; mineral oil, enemas, or salines being preferred. Specific treatment is indicated, if the stricture is of a syphilitic nature; ultraviolet light, if tuberculous in origin.

2. Operation, including: Entero-enterostomy, short-circuiting operation, enterostomy, or the formation of an artificial anus. An intestinal resection is dangerous during the period of acute obstruction with edema and inflammation. It is much safer to make a temporary enterostomy or artificial anus first, and later do the necessary resection.

Obstruction by pressure from without the intestine has one of the following origins: (1) *Uterine* pregnancy, ectopic pregnancy, tumors, inflammation; (2) *ovarian* tumors and inflammation; (3) *vesical*—large calculi, tumors, prostatic enlargement and abscess; (4) *mesenteric* growths; (5) *renal* tumors and displacement; (6) *pancreatic* cysts and tumors; (7) *splenic* tumors and splenomegalia; (8) *biliary*—enlarged gall-bladder, liver; (9) *lymphatic*, inflammations and new growths; (10) *peritoneal* and extraperitoneal inflammatory bands, masses (abscess), and tumors.

Treatment consists in removing the cause of the obstruction or, if this is not feasible, intestinal elimination by entero-enterostomy, enterostomy, or the formation of an artificial anus.

Obstruction from adhesions is frequent, and results from a cord, band, or a massive attachment of the bowel.

Etiology.—(1) A previous abdominal operation, especially one with sepsis and drainage; (2) a previous peritoneal inflammation, as from appendicitis, peptic ulcer, tuberculosis, peritonitis, or typhoid; (3) a congenital band or adhesion from the mesogastrium, Meckel's diverticulum or other congenital defect.

Symptoms are those of an acute ileus, often followed by those of peritonitis.

Diagnosis.—Obstruction from a band of adhesions is to be suspected with the evidence of a previous serious abdominal operation or inflammation, especially if the history or cicatrix indicates a drained or suppurating wound.

Fig. 838.—Adhesions constricting sigmoid. (Roentgenogram by Dr. G. C. Bird.)

Prognosis depends upon the promptness in operating. The mortality is high, if gangrene and peritonitis have developed.

Treatment.—Immediate operation. Early in the obstruction, the simple division of a band or cord often is all that is required, and the mortality is low. Later it is usual to find gangrene of the bowel from pressure, necessitating intestinal resection or the formation of an artificial anus, and the mortality is high.

Chronic intestinal stasis with absorption of toxic matter may result from intestinal atony, or the presence of prenatal or acquired peritoneal bands or sheets of membrane, especially over the lower ileum and colon—as *Jackson's membrane*, *Jackson's veil*, *Lane's kink*, or *Price's elbow*. Payr's disease is due to a kink at the splenic flexure of the colon.

Intestinal stenosis may follow the healing of an ulcer or traumatic injury (contusion, strangulation, suture, resection) of the bowel. It rarely follows typhoid fever, and is unusual from syphilis, except in the rectum. Tuberculosis is the chief cause of stenosis due to ulceration. Tuberculous ulcers, occurring chiefly in the ileocecal region, are found in over one-half of the patients dying of pulmonary tuberculosis. The long diameter of the tuberculous ulcer is usually transverse instead of longitudinal as with typhoid ulcer, and, in healing, the scar produces single or multiple stenosis of the ileum in 25 per cent. of patients.

Dysenteric ulcers may cause stenosis. Carcinoma is the usual cause after middle life. Benign tumors in rare instances cause obstruction. In stenosis, the intestine above gradually dilates, with hypertrophy of the muscular walls

Fig. 839.—Chronic ulcerative colitis in the transverse colon and sigmoid. There is a narrowing of the colon which is smooth or unhaustrated with exaggerated peristalsis and antiperistalsis. The shadow is flecked and marbled in the mucous type; in the ulcerative type there is a narrow colon shadow with delicate arborization (Carman).

due to the increased peristaltic action. Colicky pains occur, with visible noisy peristalsis.

Diagnosis.—Tuberculous stricture usually develops between the age of twenty and thirty, in patients with cachexia and evidence of tuberculosis in the lungs or elsewhere. Malignant strictures chiefly occur after forty years, and may be shown by the roentgenogram.

Treatment is operative resection and anastomosis or a short-circuiting operation by entero-entero-anastomosis.

Ulcer of small intestine is rare, except the marginal ulcer following gastro-enterostomy, and the ulcers due to parasites, foreign bodies, typhoid, tuberculosis, actinomycosis, diverticulitis, or carcinoma.

Operation is required for perforation with local or diffuse peritonitis, severe hemorrhage, stenosis, or an ulcerating tumor.

Ulcer in Typhoid.—*Pathology.*—The shape and longitudinal extent of the ulcer is determined by that of lymphoid masses involved; the site, by stagnation of intestinal contents above the ileocecal valve and richness in lymphoid tissue. The axis of the ulcers being longitudinal, secondary strictures are unlikely. As the lymphoid aggregates have their bases in large lymphoid sinuses, the mesenteric and retroperitoneal glands are early involved. *Perforation* is most frequent in the lower ileum, due to the richness in lymphoid follicles, the immobility, the pressure needed to overcome the resistance of ileocecal valve, and the thinness of the intestinal wall. The colon is thicker, has less lymphoid tissue, and usually is less ulcerated. Perforation involves the ileum in 60 per cent., the large intestine in 12 per cent., the appendix in 2 per cent., while multiple perforations are present in 24 per cent. of the cases.

Fig. 840.—Ulcerative colitis of the descending colon associated with ovarian tumor and distended bladder.

Symptoms include a period of initial shock, a latent period, and a period of evident peritonitis.

(1) Sudden, severe pain which may be referred to the bladder and genitals, preceded at times by unusual distention (in the apathetic delirious patient, only increased restlessness may be noted); (2) shock with abrupt transient fall in temperature; (3) increase in the rate of pulse and respiration; (4) obliteration of liver dulness (this may be present without perforation), and other signs of free gas in the peritoneal cavity; (5) shifting dependent dulness over the abdomen; (6) increasing leukocytosis; (7) abdominal tension, rigidity, and other evidences of peritonitis.

Diagnosis may be difficult from the apathy and stupor of the patient. Acute abdominal pain in the third week, with rising leukocytosis and evidence of free

gas and fluid in the peritoneal cavity, an increase in local tenderness, shock with fall and then marked rise in temperature, sudden pain or tenesmus often referred to the bladder, followed later by evidence of peritonitis, suggest perforation of an ulcer.

Prognosis.—Intestinal perforation is responsible for about 2 per cent. of the deaths in typhoid. Perforation is almost invariably fatal without operation. The mortality following operation is about 60 per cent. A secondary perforation may follow the operation.

Treatment consists of immediate operation, with closure of the intestinal opening; or, better, an enterostomy by the insertion of a soft catheter in the opening in the bowel, which is fixed by a purse-string suture, to permit drainage and to reduce the pressure within the gut.

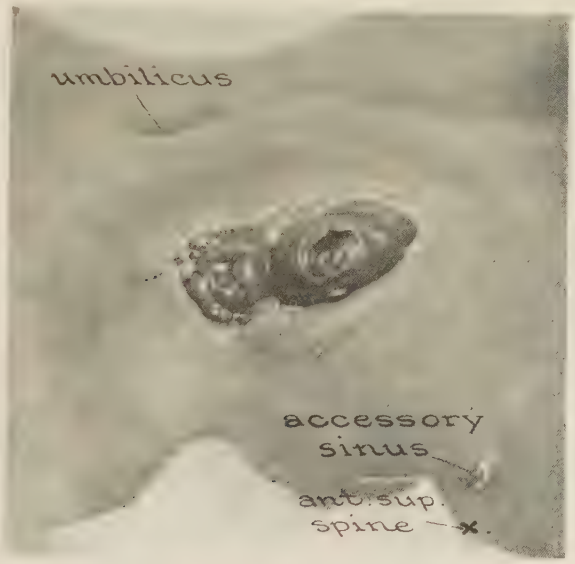


Fig. 841.—Artificial anus following gunshot injury. Closed by a three-stage operation after end-to-end suture had been followed by ileus.

Intestinal Hemorrhage from Ulcer in Typhoid.—Hemorrhage usually follows erosion of smaller vessels, although profuse hemorrhage may occur from the superior mesenteric artery. Terminal arteries encircle the gut from the mesenteric attachment, and run for a short distance immediately beneath serosa; then perforate the muscular layers, and ramify from the submucosa. Thus, typhoid ulcers being opposite the mesentery involve the arterioles earlier than ulcers close to the mesenteric attachment.

Symptoms.—Painless shock, pallor, weak rapid pulse, increasing leukocytosis, restlessness, and air-hunger, followed after four to twelve hours by copious tarry stools.

Treatment.—Ice-cap to abdomen, Fowler's position to reduce the blood-pressure, calcium chlorid and thromboplastin intravenously, small transfusion of whole blood. Rectal tube to reduce tympany.

External intestinal fistulæ arise from: (1) Penetrating or non-penetrating wounds with intestinal injury; (2) ulcerated, incarcerated, or gangrenous hernia; (3) ligation of umbilical cord, containing intestine; (4) ulceration from retained drains, sponges, pads, or other foreign bodies; (5) ulceration from appendicitis, diverticulitis, carcinoma, tuberculosis, actinomycosis.

Fistulæ from *appendicitis*, *tuberculosis*, and *actinomycosis* are found in the lower right abdominal quadrant; from *tumors*, in the region of the umbilicus; and from *diverticulitis* or *carcinoma* of the sigmoid, in the lower left abdominal quadrant.

The fistula may be *direct*, immediately opening upon the abdominal wall; or *indirect*, in which a cavity or space exists between the intestine and the abdominal wall. It is lined by mucous membrane or granulations.

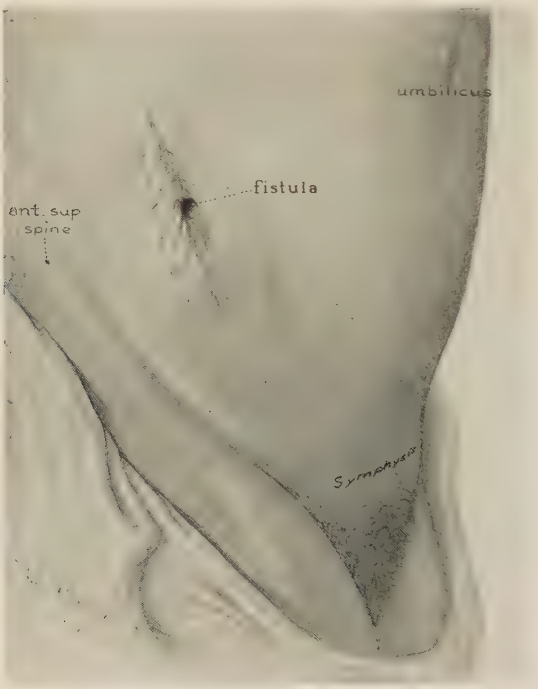


Fig. 842.—Cecal fistula following operation for appendiceal abscess with drainage.

A *fecal* or *intestinal fistula* discharges a part of the intestinal contents; *artificial anus*, all the contents of the intestines. The attached intestine tends to draw away from the anterior abdominal wall, forming a spur. The mucous membrane from the afferent loop may protrude from peristaltic action. An intra-abdominal hernia may occur; or the intestine may prolapse (mucous side out) through the fistulous opening, and become strangulated.

The *effect upon the general health* varies with the situation, the size of the opening, and with the amount of nourishment lost through the fistula. If in the lower ileum or colon, there is little effect upon the general health. The frequent discharges may cause erythema, eczema, and ulceration on the abdominal wall about the fistula.

Diagnosis is made from: (1) The character of the discharge, as bile, intestinal contents, or gas; (2) the passage *per anum* of colored fluid injected into the fistula, and (3) Roentgen examinations after the injections of solutions or pastes opaque to the rays. With an artificial anus and double opening, the proximal opening is larger and shows a greater tendency to prolapse than the distal.

Treatment.—Relief of skin irritation is best obtained by the removal of all dressings, and frequent cleansing with boric lotion. The skin should be kept dry by a coating of zinc-stearate powder, and by exposure to the air under a bed cradle containing an electric light. Ointments should not be used, as they absorb the secretions and hold them in contact with the skin. From exposure to light and air, with zinc-stearate protection, excoriations rapidly heal.

Fig. 843.—Abdominal fistulectomy: The opening is cleansed, injected with methylene-blue solution, and plugged with gauze wrung out of zinc chlorid solution. The old scar is liberated for excision.

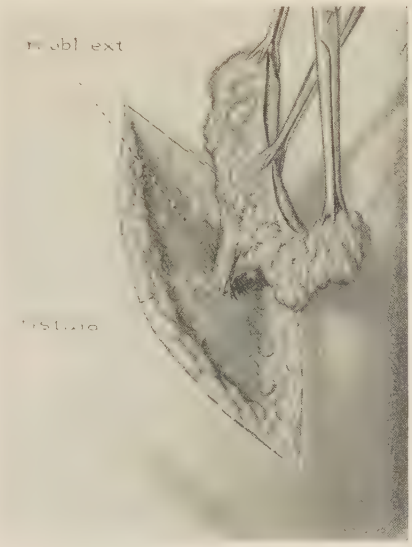


Fig. 844.—Abdominal fistulectomy: The scar is liberated, inverted, and clamped, and guided by the methylene-blue color, the fistulous tract carefully isolated without opening it to the cecum, where it is divided by cautery between clamps, and the stump inverted as in appendectomy. The wound is then carefully closed in layers without drainage.

Palliative treatment consists in the use of an enterostomy-bag or belt for catching the discharges, or plugging the opening with iodoform gauze impregnated with zinc stearate and compound tincture of benzoin.

Operative Treatment: Mikulicz's three-stage operation. If the condition is due to tuberculosis or actinomycosis, the outlook from the operation is less favorable, and the special constitutional and local treatment should be used.

Carcinoma with Fistula.—Usually the disease has passed beyond the stage of any but palliative treatment, and operation is not to be considered.

Internal intestinal fistulæ occur between contiguous organs, being entero-intestinal, gastro-intestinal, vesico-intestinal, nephro-intestinal, uretero-intes-

tinal, and the like. Cholecysto-intestinal fistulæ are produced by the ulceration of gall-stones from the gall-bladder into the intestines. Often no characteristic symptoms follow, although a slow and progressive cholangitis may result. Internal fistulæ are produced by gastric ulcer, and by the marginal ulcer following gastro-enterostomy, particularly between the stomach, jejunum, and transverse colon. A jejunal fistula, very difficult to close, follows injury to the jejunum during the operation of a right nephrectomy. In the sigmoid, internal fistulæ to the intestine, bladder, or other part frequently result from diverticulitis. An entero-uterine or enterovaginal fistula, with a discharge of intestinal contents through the uterus or vagina, follows intestinal injury during operation upon the uterus or vagina. From the bladder, fistulæ are usually formed with the rectum (from perineal prostatectomy, hysterectomy, application of the actual cautery or radium to the uterus), the sigmoid or, less frequently, the small intestine or appendix. From an enterovesical fistula there is discharge of gas and fecal-stained urine by the urethra or frequent bowel movements liquefied by urine.

Treatment.—Small fistulæ may close spontaneously; larger ones, and those producing symptoms, should be treated by operative separation and closure of each organ involved. Certain involved organs, such as the gall-bladder, appendix, kidney, are best removed. If from advanced carcinoma or tuberculosis, operative treatment is as a rule unsatisfactory.

Giardiasis is an intestinal infection, chiefly of children, from the Lamblia intestinalis. About 25 per cent. of children and 3 per cent. of adults show the presence of giardia cysts. The cysts are killed in five minutes by a temperature of 64° C., and by drying, but may live in distilled water for months, withstand ingestion by flies, and may be carried by pets and rats.

Giardiæ, formerly considered harmless, produce in children irritation of the intestinal tract, diarrhea, malnutrition, possible secondary intestinal infection, and retardation of growth.

Treatment.—Bismuth salicylate, 2 to 5 grains every two to six hours.

Typhlitis, Perityphlitis (Abers de Bonn, 1836).—Cecitis is rare without involvement of the appendix. One or 2 per cent. are primary, 98 per cent. are secondary to appendicitis. *Typhlitis stercoralis* is believed to be due to a *decubitus ulceration* of the cecal mucosa from pressure of a fecal mass.

Etiology.—Pressure of fecal masses, foreign bodies, parasites.

Pathology.—The infection may localize in the ulcerated cecal wall, produce localized pericecal abscess or a circumscribed indurated mass, or a scar and cicatricial deformity of the caput coli. Secondary malignant changes may occur.

Symptoms.—Constipation is usually present (or constipation alternating with diarrhea) with nausea and vomiting, increased temperature, leukocytosis, localized tenderness, at times rigidity, and occasionally a mass. Gangrene of the cecum may occur with perforation or obstruction. Primary perityphlitis is to be differentiated from carcinoma, tuberculosis, actinomycosis, appendicitis, or abscess. It is difficult to differentiate from appendicitis.

Treatment.—(1) Appendectomy; (2) incision and drainage of any abscess; (3) resection of the cecum is dangerous while an active inflammation is present, a short-circuiting operation or cecostomy is preferable.

Intestinal diverticula, either single or multiple, occur chiefly in the sigmoid, tend to enter the fatty tabs, and to cause rotation of the bowel toward the mesenteric attachment. They collect and retain fecal masses, with a tendency to irritation, ulceration, and perforation.

Diverticulitis: The inflammation of intestinal diverticula (Virchow, 1853).

Pathology.—Serious inflammation rarely occurs, except with diverticulitis of the sigmoid. The walls of the diverticulum undergo fibroconnective tissue thickening, and ulceration with the formation of a mass. The small neck may contract and become obstructed. Abscess formation and perforation into an adjoining viscus or the peritoneal cavity frequently occur. Diverticulitis is a common cause of internal or external intestinal fistula after middle life.

Etiology.—Diverticulitis occurs chiefly in constipated, obese (17 per cent.) men, who are over fifty years of age. Physicians are often affected.

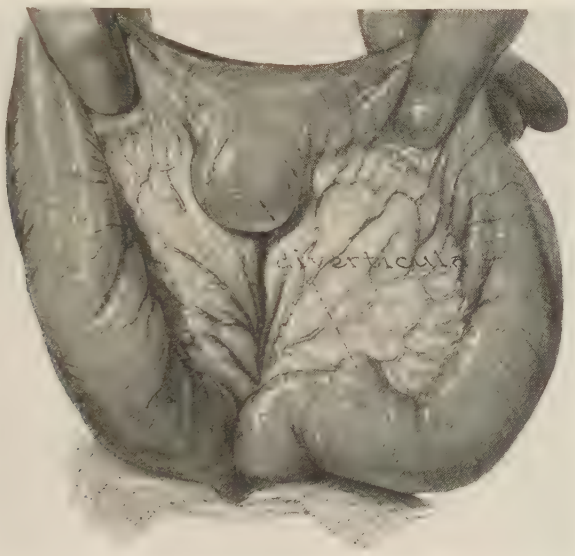


Fig. 845.—Two diverticulæ of the ileum.

Symptoms include: (1) Chronic constipation; (2) chronic catarrhal colitis, with passage of blood-stained mucus; (3) pain is present in 63 per cent., usually with increased resistance and tender mass in lower left quadrant; (4) acute inflammation, with sudden acute pain in a lower abdominal quadrant or the pelvis, tenderness, fever, leukocytosis, and the development of a mass or fistula; (5) perforation usually occurs into the bladder, with the passage of gas and feces with the urine. Vomiting of fecal material occurs if the perforation is into the stomach; (6) mental depression, lethargy, and headache; (7) 40 per cent. result in carcinoma.

Diagnosis.—The development of a tender mass in the lower left abdomen in a man, over fifty years of age, who is obese and has chronic constipation, with evidence of perforation into an adjacent organ, and a pocket or fistula of the sigmoid as shown on the roentgenogram, indicate diverticulitis. Diverticulitis is

to be differentiated from appendicitis, acute cystitis, intestinal carcinoma, and cholecystitis.

Treatment.—Only a stage or palliative operation (as that of Mikulicz), an enterostomy or colostomy, should be used during the period of acute inflammation or obstruction.

For chronic diverticulitis, the separation of adherent viscera, closure of fistulous openings, and usually resection and anastomosis of the colon are required.

Intestinal Cysts.—Gas-cysts: An unusual condition, similar to one occurring in hogs, in which large areas of both small and large bowel are involved, with bubble-like or foam-like masses between the layers of the intestinal wall, from the submucosa to the serosa. Only about 100 cases have been reported.

Etiology is obscure. It may be bacterial, neoplastic, chemical, or mechanical. Probably the cause is mechanical, pressure forcing the intestinal gases into the lymph-channels and tissue-spaces of the intestinal wall. The condition is associated with tuberculous peritonitis (50 per cent.), ulcer, other benign processes of the stomach or intestine, or cancer.

Symptoms are not characteristic. The condition suggests appendicitis, peritonitis, acute or chronic intestinal obstruction or, again, few symptoms are evident. The abdominal wall is ballooned, flaccid, and easily depressed, but tympanitic and, at times, crepitant. There is pressure upon the diaphragm, causing palpitation, tachycardia, and dyspnea on exertion. The digestive disturbances range from constipation to intermittent diarrhea.

Treatment.—Operative exploration and puncture of the cysts, or (in extreme cases with obstruction) an enterostomy, a short-circuiting operation, or an intestinal resection and anastomosis may be necessary.

Congenital ileocecal or **mucous cysts** originate close to the ileocecal valve, are lined by mucous membrane, and contain glairy mucus or semisolid material. They may develop from a diverticulum or from retention in glands of the mucosa, and be so large as to fill the abdomen. Usually they cause symptoms during the early months of life, but occasionally do not attract attention until adult life.

Diagnosis.—The mass, being in the interior of the cecum, must be differentiated from an intussusception.

Treatment.—Operation with (1) enterotomy and excision; or (2) drainage into the intestinal lumen; or, to relieve urgent symptoms, (3) a short-circuiting operation.

Tuberculosis of the Intestines.—*Tuberculous ulcers* are found in over half of the cases of advanced pulmonary tuberculosis, and are the most frequent cause of stenosis of the small intestine. They chiefly involve the cecum and ileocecal valve.

Etiology.—From a primary tuberculous disease in the lungs, infection occurs from swallowed sputum, or through the blood-stream or lymphatics. Rarely a primary pulmonary focus is absent. The ulcers occur in both sexes between the ages of twenty and forty years, and are occasionally found in youth and childhood.

Varieties.—1. *Solitary* or *multiple small superficial ulcers*, chiefly in the

ileum, and tending to heal if there is not extensive tuberculous disease of other organs. The long axis of the ulcer is transverse to the intestine.

2. *Hyperplastic form, large infiltrating ulcers* or polypoid granulations upon the mucous membrane, partially annular, and tending to stenosis and stricture. In one-fourth, the condition is multiple; the bowel above the stricture is hypertrophied or dilated, or both thick and dilated. The ulcers show dense fibrous hyperplasia, with limited caseation and necrosis, but with stenosis, obstruction, and enlargement of the regional lymph-nodes. The hyperplastic form is found between the ages of twenty and forty, rarely in children and the elderly.

3. *Enteroperitoneal*, a tuberculous infiltration with tumor formation, usually involving the ileocecal region, with: (a) Thickening and infiltration of the intestinal wall; (b) caseation and ulceration involving the serous, mucous, and submucous coats; and (c) little tendency to stricture. The muscular layer resists tuberculous invasion. A hard, nodular, cylindric tumor forms, not moving with respiration but movable by the hand, later becoming adherent and fixed. Finally peritoneal adhesions and abscesses form, with perforation (fecal fistula) into the adjacent parts, as the bladder, intestine, pleura, abdominal wall, or veins. This form may occur at all ages, and may last for years.

Symptoms.—*Clinical Picture:* A patient, between twenty and forty years of age, gives the symptoms of chronic intestinal stenosis, or has alternating constipation and diarrhea. There is cachexia, wasting, anorexia, colic, rumbling, occasionally vomiting, visible peristalsis, rarely blood in the stools. A firm, hard, nodular, usually cylindric tumor is felt, most frequently in the ileocecal region. The mass is not tender or painful, does not move with respiration, but may be moved by the fingers. There is little or no fever, unless an abscess forms. The condition persists for years, the patient finally dying from intestinal stenosis, tuberculosis of the lungs or peritoneum, or from complications.

The *hyperplastic form* is chronic and insidious, with indigestion, emaciation, constipation, colic, borborygmi, vomiting, swollen tense abdomen, visible peristaltic waves; and with a painless, hard, movable tumor, usually in the right inguinal region. The condition may be mistaken for cancer of the cecum.

Enteroperitoneal Form: A tender inflammatory mass occupies the right iliac fossa. There is diarrhea with the passage of mucus and blood, and later the formation and rupture of abscess, with secondary inguinal, femoral, lumbar, or umbilical fistula. Tuberculosis of the lung is often associated.

Diagnosis.—*Syphilis* frequently causes stenosis in the pelvic colon and rectum, rarely the small intestine or cecum. *Tuberculosis* is the most common cause of stenosis or tumor-like mass involving the small intestine in a person under forty. Evidence of an associated or pre-existent pulmonary lesion is usual. The diagnosis is to be made from chronic appendicitis or carcinoma.

Treatment.—Disseminated intestinal tuberculosis and the uncontrollable diarrhea of advanced pulmonary tuberculosis cause a hopeless condition not amenable to surgical treatment. Where the disease is less extensive and the patient has better resistance, healing may occur under rest, diet, fresh air, and ultraviolet light or sunlight to the abdomen. Internally, 5 to 10 minims of well diluted aromatic sulphuric acid may be given every two or three hours, or 1 to 3 minims of Beechwood creosote in pill or solution every three hours. If

the diarrhea is troublesome, 0.3 to 0.5 gm. of bismuth subiodid, given every three or four hours, is of value. About 70 per cent. of secondary cases of intestinal tuberculosis are improved by heliotherapy, and healing may occur despite the absence of improvement in the primary pulmonary tuberculosis. A ten-minute exposure of one-quarter of the body, with a lamp at a distance of 12 inches, is used daily, the treatment being continued for ten months or longer, as necessary.

Operative excision, with intestinal anastomosis, is to be considered in well-localized hyperplastic or enteroperitoneal forms of intestinal tuberculosis, especially when the patient shows a decided resistance to the disease.

Actinomycosis involves, in order of frequency: (1) The head and neck; (2) the abdomen; (3) the lung, and finally (4) the skin and tongue.

The *abdomen* is involved in 20 per cent., the disease usually beginning in the appendix or cecum from contaminated cereals or the flesh of diseased animals. The location in order of frequency is: Appendix, cecum, colon, rectum, small intestine and, very rarely, stomach.

Symptoms.—(1) Stage of *early infection*, usually without symptoms; (2) stage of *tumor formation;* (3) stage of *suppuration* and fistula formation.

In the first stage, intestinal catarrh is usual, but may be intermittent or absent. In the second—a tumor, usually fixed to the abdominal wall, hard, not clearly differentiated and, rarely, accompanied by pain or tenderness, is present. In the third stage—fluctuation, abscess formation, and sinuses occur.

The granulations are very vascular and bright red, the discharge is seropurulent, thin or stringy, and contains the characteristic granules. The parasite does not tend to spread into lymph-channels or lymph-nodes. The overlying tissues become indurated, with a characteristic bluish-red discoloration of the adjacent skin, sinus formation, and purulent discharge containing the small granules, and having a characteristic earthy odor.

Chronic Form.—There is local irritation in the cecal region, with dull pain, occasionally intestinal colic or irritability, usually diarrhea; and a slowly growing, painless, rather fixed tumor develops in the right iliac fossa. Later abscesses form, with sinuses, in the abdominal wall. Actinomycosis should be suspected, when a persistent sinus follows the drainage of an appendiceal abscess.

A firm, slow-growing mass, not impairing the general health, may exist for months or years with sinus formation. Intestinal stenosis is rare. There is irregular fever, which may be high if there is extensive infection of the mucous membrane; emaciation, and finally amyloid degeneration of the liver, spleen, and kidneys, with anemia. Fecal fistula and generalized peritonitis are rare. The abscesses tend to invade the bladder, kidneys, and pleura. Metastatic growths are most common in the liver. The *pyemic* or *general miliary form* is rare, and is due to the rupture into a vein of an abscess containing the spores, with secondary dissemination and foci in the lungs, liver, and other organs. It is rapidly fatal.

Diagnosis is made by finding the characteristic gray or yellowish granules (consisting of clubs, threads, and rounded bodies resembling micrococci) in the pus. The diagnosis is difficult without examination of tissue or discharge. The chronic course, with an ill-defined infiltrating tumor that gradually softens, is

to be differentiated from carcinoma, tuberculosis, chronic appendicitis, or an abscess or tumor of the abdominal wall. The appendix may become gangrenous or perforated, resembling an ordinary acute appendicitis.

Prognosis.—Spontaneous cure of abdominal actinomycosis is doubtful. The average duration of life is three years. The mortality of abdominal actinomycosis under treatment is 70 per cent. Death occurs from cachexia and the extension of the disease to the liver and thorax. Complete extirpation of the disease when limited to the appendix or cecum is followed by recovery.

Treatment.—Intermittent use of large doses of iodid of potassium, Roentgen ray, and ultraviolet light. Potassium iodid does not destroy the parasite or its spores, but favors softening and limits extension of the disease. As the organism is anaërobic, the opening of sinuses with free exposure to the air inhibits their growth. Complete excision is rarely possible. Incision, partial excision, curettage, applications of a 2 per cent. solution of nitrate of silver, with radiation and the iodid treatment, are followed by cure in 25 to 30 per cent. Operation alone offers only 16 per cent. of cures, with a mortality of 30 per cent.

Fig. 846.—Polyposis of the colon (Carman, Mayo Clinic).

Tumors of the intestine chiefly involve the lower bowel, the majority being carcinomata.

The **benign tumors** include: Papilloma, fibroma, myxoma, lipoma, angioma, lymphoma, endometrial adenoma, and cystic growths. They are rather rare and are only important when they produce: (a) Obstruction; (b) invagination; or (c) ulceration and diarrhea.

Diagnosis is made by: (1) Symptoms; (2) rectal examination by finger, proctoscope, and sigmoidoscope; (3) Roentgen examination.

Symptoms may be absent, or invagination, irregular peristalsis, alternating diarrhea and constipation, or obstruction may occur.

Tumors of Small Intestine.—Both benign and malignant tumors of the small intestine are rare. *Benign tumors* include adenoma, lipoma, fibroma, myoma, myxoma, angioma, teratoma.

Adenomata arise from the glands of Lieberkühn as small, pediculated, sessile, solitary or multiple growths, from 1 to 8 cm. in diameter. Usually they develop in youth, but may occur at any age. Multiple polypoid adenomas are occasionally found, especially in the region of the ileocecal valve.

Lipomata usually arise from the submucosa, being sessile or polypoid, and frequently causing intussusception.

Myomata develop in the muscular layer, being submucous or subserous.

Endometrial Adenomata (*Endometrial Implantation*).—Tumors of tissue corresponding to the endometrium chiefly involve the pelvic organs and adjacent

structures of women. In the intestine they may cause obstruction and death. The lesions are often multiple, and menorrhagia may be associated. They are

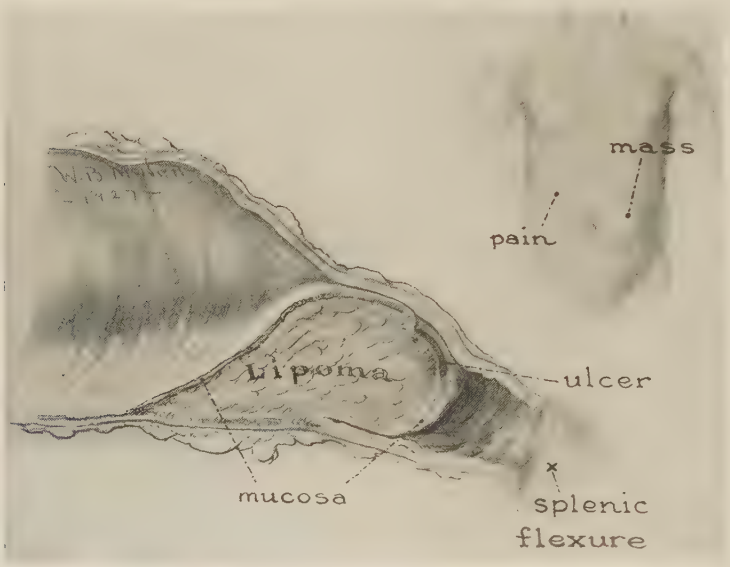


Fig. 847.—Ulcerating ball-valve lipoma of the transverse colon. Patient aged twenty-four. Symptoms of partial intestinal obstruction, with tarry stools for two years, followed by those of acute obstruction. Barium was arrested at the splenic flexure. The tumor, the size and shape of an egg, tended to slip into the splenic flexure, producing obstruction with pain and tympany in the upper right quadrant. Colotomy and enucleation by Dr. John V. Hartman, with recovery.

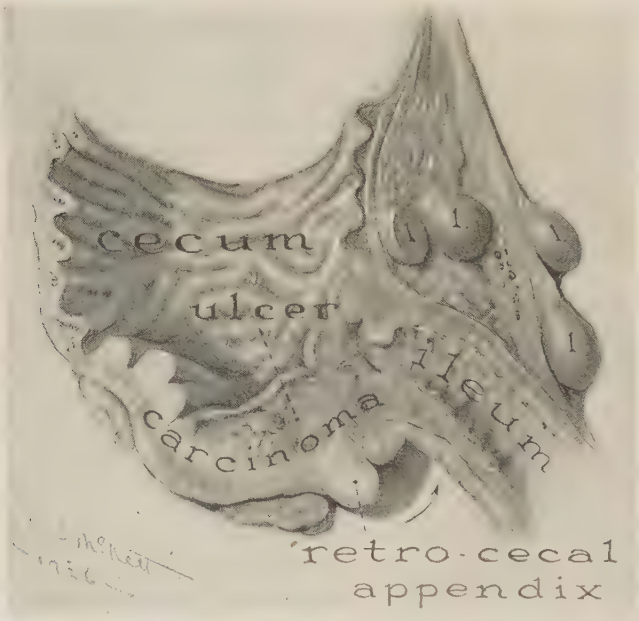


Fig. 848.—Ulcerating scirrhous carcinoma of the cecum involving the ileocecal valve: 1, Enlarged lymph-nodes. An ileocecectomy and ileocolostomy were performed.

most serious when forming the so-called chocolate cysts (Sampson). Removal of the ovaries may be followed by cessation of the growth and atrophy of the endometrial tumor.

The treatment is bilateral oöphorectomy with or without surgical extirpation of tumor.

Carcinoma of small intestine comprises only 3 per cent. of intestinal cancers.

Site: (1) Duodenum in middle or periampullary section; (2) the ileum, and least frequently (3) the jejunum.

Pathology.—(1) Polyposis; (2) single or multiple, embryonal, carcinoid tumors in the mucosa or submucosa; (3) adenoid carcinoma; (4) scirrhous carcinoma (rare). The growth may be annular and stenosing, polypoid, a fungous ulcer, or a diffuse colloid infiltration of the bowel.

Origin from the basal epithelial cells, the cylindric epithelial cells, or the crypts of Lieberkühn.

Etiology.—Middle life, average age forty-six years; only occasionally under twenty years.

Symptoms.—In the duodenum 20 per cent. involve the ampulla, with painless jaundice, emaciation, and enlarged gall-bladder (*Courvoisier's syndrome*).

In the ileum a polypoid growth often causes intussusception. Other symptoms include colic, diarrhea, hemorrhage, irregular, visible peristalsis, and obstruction.

Prognosis.—Grave. Metastasis occurs to the mesenteric glands, liver, lungs, and peritoneum. Colloid carcinomas are of slow growth and lower malignancy.

Treatment.—Early and wide excision by one- or two-stage enterectomy.

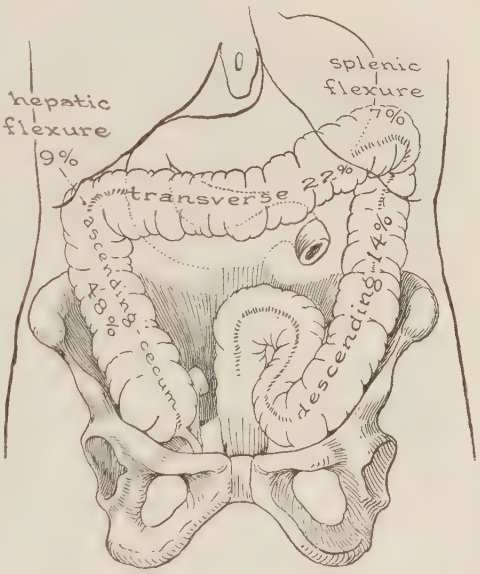


Fig. 849.—Illustrating the incidence of carcinoma in various parts of the colon, except the sigmoid and pelvic colon.

Carcinoma of the Colon.—In the large intestine, 55 per cent. of carcinomas involve the pelvic colon and sigmoid. Above the rectum, cancer is most frequent in the sigmoid, then in the cecum, then the hepatic and splenic flexures, and occasionally the transverse and other parts of the colon.

Varieties.—Carcinoma of the intestine is always of the columnar-cell variety, and may be a scirrhous, medullary, or colloid carcinoma or adenocarcinoma.

Etiology.—(1) Male sex—three men to one woman. (2) Age—over forty-five years; occasionally between ten and twenty years, especially with carcinoma of the rectum. (3) The cancer is usually primary and solitary. (4) Diverticulitis, ulceration, stricture, or chronic constipation may predispose.

Symptoms.—1. Chronic obstruction with irregular abdominal colic, abdom-

inal distention, borborygmi, visible and audible peristaltic waves, constipation alternating with diarrhea. Tenesmus is present with carcinoma of the pelvic colon or rectum, or if there is invagination, proctitis, or periproctitis.

2. Acute or recurrent attacks of obstruction, directly from enlargement of the growth, or from secondary kinking, invagination, or volvulus of the intestine.

3. Tumor may be felt through the abdomen or rectum, or seen through the proctoscope. Annular constricting carcinomata of the hepatic or splenic flexures usually are not palpable.

4. Diarrhea: (a) With an ulcerating fungating carcinoma, the diarrheal discharges contain blood and decomposing tumor-fragments, and have a peculiar, very offensive odor; (b) early morning diarrhea is a very important symptom of carcinoma of the pelvic colon; (c) profuse mucous and serous diarrhea, with little fecal matter, is a symptom of papillary growths having many secreting glands.

Fig. 850.—Carcinoma of the transverse colon (Carman).

Fig. 851.—Carcinoma of the cecum (Carman).

5. Cachexia, emaciation, and ascites are late symptoms which indicate an advanced and hopeless stage of the disease.

The growth is either (a) annular or ring-like; (b) tubular; (c) ulcerated; or (d) a polypoid or fungating mass.

Metastasis: Scirrhous carcinoma usually is transferred by the portal vessels to the liver; medullary carcinoma through the lymphatics to regional lymph-nodes; the colloid or gelatinous type to the peritoneum, lymph-vessels, and bones rather than the liver (Hauser).

Complications: (1) Stenosis, and not infrequently acute obstruction occurs, especially with an annular contracting growth; (2) ulceration and perforation into the peritoneal cavity, abdominal wall, or other viscus; (3) mucous diarrhea from glandular overgrowth; (4) ulceration with foul bloody diarrhea; (5) invagination; (6) intussusception; (7) infiltration and contraction of the adjacent mesentery are not unusual.

Diagnosis is made from the symptoms, a digital rectal and abdominal exam-

ination, proctoscopy and Roentgen study, and the presence of free or occult blood and tumor fragments in the stools. Diagnosis is seldom made from ribbon or pipestem-shaped stools. In case of doubt an exploratory operation is indicated. A small annular carcinoma may be detected, with difficulty, even by the hand in the abdomen. An enlarging tender mass in the groin develops at times from perforation into the abdominal wall, or an acute cystitis and pneumaturia from perforation into the bladder. The differentiation from diverticulitis may be difficult without a biopsy.

Prognosis.—Duration of life with carcinoma of the colon is three to five years, if obstruction is prevented by colostomy or other measures; if of the small intestines, six months to two and one-half years. The duration of life is progressively greater, the lower the situation of the growth; with the exception

Fig. 852.—Filling defect in sigmoid from carcinoma. Colon distended by barium enema. (Roentgenogram by Dr. G. C. Bird.)

of cancer of the rectum. Operative eradication is contraindicated by advanced cachexia, a fixed adherent infiltrating tumor, craggy aortic lymph-nodes, ascites, peritoneal or visceral metastasis.

Treatment.—1. Palliative: The swelling, irritation, and growth of the tumor is reduced by an operation that eliminates the diseased portion of the intestine from the fecal current, as an artificial anus, entero-anastomosis, or intestinal elimination.

2. Radical Excision: The growth, with at least 8 cm. of apparently healthy bowel above and below, and the adjacent mesentery is resected by a single or stage operation. For sigmoid growths the stage operation of Mikulicz reduces the chance of peritonitis and gives a better prognosis. For growths in the pelvis a preliminary colostomy may be followed later by excision through the

Fig. 853.—Annular carcinoma of the sigmoid.

Fig. 854.—Enormous hematoma of appendix epiploica impacted in the pelvis. The sac had a thin, black peritoneal covering fixed by recent adhesions and resembled an ovarian cyst, but was connected to the sigmoid by a pedicle 5 cm. long and twisted 180 degrees. The patient, twenty years old, had symptoms of recurrent partial intestinal obstruction for six months associated with retention of urine. Operation for acute obstruction by Dr. John V. Hartman, with recovery.

abdomen or perineum (Kraske's operation). In the terminal stages the free use of opiates and hypnotics to relieve pain is desirable.

Sarcoma of the intestine is rare. It is relatively more frequent in the small intestine. Round or (less frequently) spindle-cell, alveolar, or melanotic sarcoma, cystosarcoma, lymphosarcoma, myxosarcoma, or endothelioma occur. A sarcoma usually begins in the submucosa, involves a greater length of intestine than carcinoma, invades adjacent organs, and metastasizes to the liver, kidneys, spleen, and retroperitoneal lymph-nodes. With rare exceptions it does not produce stenosis or obstruction, but tends to enlarge the lumen of the bowel.

Symptoms.—A rapidly growing tumor, without obstruction, at first freely movable, followed later by metastatic growths, loss of weight, cachexia, and ascites. The duration of life averages about one year.

Treatment is rarely successful, and consists of operative extirpation and irradiation.

Appendices epiploicæ or **omentula** are subject to torsion, inflammation, adhesion, with obstruction or detachment. Torsion may cause subperitoneal hemorrhage or chronic inflammatory changes, fat-necrosis, and gangrene. With chronic infection, cyst formation, adhesions, and calcification occur. Intestinal obstruction results from adhesion, or from the appendage encircling the gut. When detached and lying in the free abdominal cavity, a hardened calcified mass or cyst forms, varying in size from that of a pea to a hen's egg. Omentula entering a hernial sac are subject to strangulation, torsion, and inflammation, and may cause an acute abdominal crisis, with vomiting, rigidity, pain and tenderness, suggesting an inflamed, irreducible hernia.

Treatment.—Resection or removal of the necrotic or inflamed appendage, drainage of abscesses, release of constrictions.

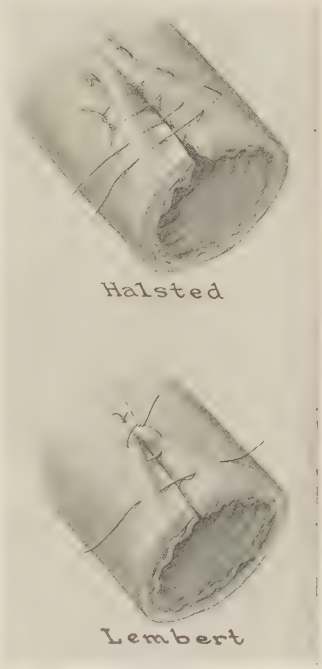


Fig. 855.—Intestinal sutures; interrupted sutures of Halsted and Lembert. The tough submucosa should be caught by the needle to obtain sufficient support.

OPERATIONS ON THE INTESTINE

Healing of peritoneal wounds occurs by primary or secondary intention, with peritoneal exudate and inflammation of subserosa. Primary adhesion through exuded plastic lymph occurs between the serous surfaces in from twenty minutes to two hours. The formation of adhesions depends directly upon the acid reaction of the tissues. The more the cells swell and the greater amount of water they absorb, the greater the adhesion. Fibers soon form in the fibrinous exudate. By the second or third day mitosis and fibroblast formation occurs in the edematous subserosa, with numerous thin precollagen fibers that grow between the collagen fibers and the endothelial cells

into the adhesive exudate, to unite with similar fibers from the other side. These thicken, and also change into true collagen fibers. Vascularization of the granulation tissue begins at the end of twenty-four hours by endothelial processes from the nearest capillaries. By the third day the granulation tissue is well vascularized; on the tenth day arterial and venous capillaries are present. By the twenty-seventh day arteries and veins have formed.

After Suture of Peritoneal Surfaces.—By the sixth or seventh day the tissues are soft and edematous, the sutures have loosened or have been partially absorbed, and the line of union is weaker than at any other time. If a united wound into a hollow viscus is separated and resutured at this time, reopening of the wound and failure of suture will often follow. Therefore, if possible, resuture of an opening into a hollow viscus should not be done until the edema

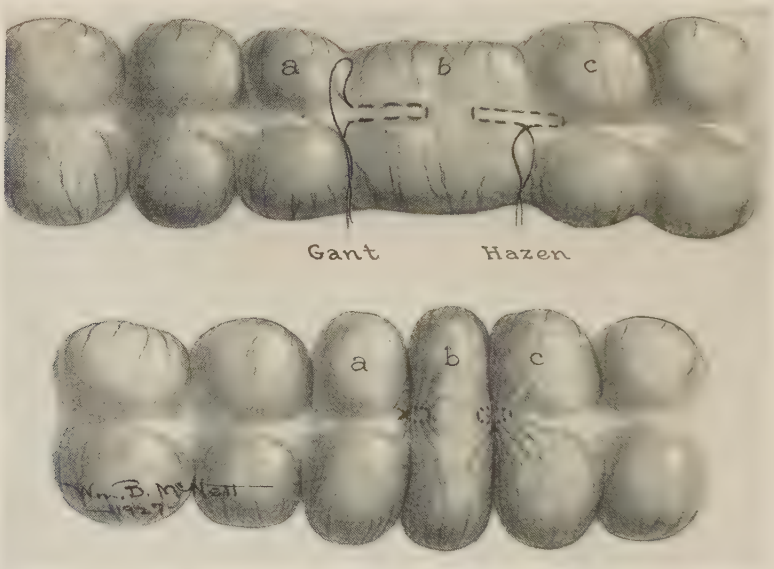


Fig. 856.—Methods of shortening the elongated colon by plicating sutures introduced into the tænia libera.

has subsided and the tissues are well organized. Fine round needles without cutting point or edge, such as the ordinary cambric needle of the seamstress, should be used for intestinal suture.

Intestinal *suture materials* include: (1) 0, 00, or 000 chromic catgut, which is slowly dissolved; (2) fine, preferably black silk, thread; (3) linen thread, or *Pagenstecher* (a linen thread made less absorbent by impregnation with celluloid). Non-absorbent threads are encysted or ulcerate into the lumen of the bowel. Silk or linen sutures may hang from the mucous edges along a line of suture for weeks or months, and are a factor in the marginal ulcer following gastro-enterostomy.

Intestinal Sutures.—(1) *Lembert's suture*—interrupted seroserous suture, which catches the resistant submucosa as well as the serous coat; (2) *Dupuytren's suture*—a continuous Lembert suture; (3) *Czerny's suture*—an interrupted

suture of the intestinal margin; (4) *Albert's suture*—a through-and-through suture of the intestinal margin; (5) *Halsted's suture*—a square mattress-suture of the Lembert type; (6) *Cushing's suture*—a continuous serous suture, the bights being taken along a straight line parallel with the line of anastomosis; (7) *Connell's suture*—a continuous through-and-through suture for end-to-end anastomosis of the intestine, applied from the mucous side and so arranged that all knots are within the lumen.

Fig. 857.—Interrupted intestinal sutures. The Czerny-Lembert suture.

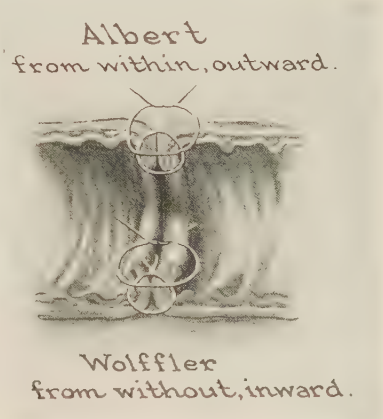


Fig. 858.—Interrupted intestinal sutures of Albert and of Wölfler.

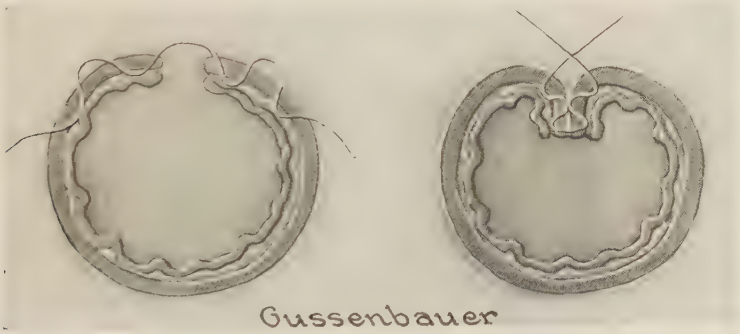


Fig. 859.—Gussenbauer's interrupted intestinal suture.

Fig. 860.—The Gould and the Cushing intestinal sutures.

Intestinal ligation for closing the ends of the bowel. The bowel is first crushed, ligated in the groove formed by crushing, and the stump inverted by a surrounding purse-string or other inverting type of suture.

Fig. 861.—Continuous intestinal sutures, using two needles and two threads. The cobbler, the bootlace, the Gely sutures. These sutures are rarely used.

Intestinal Operations.—(1) *Enterorrhaphy*—suture of the intestine; (2) *enterotomy*—cutting open the intestine; (3) *enterostomy*—formation of an artificial opening into the intestine; (4) *enteroplasty*—a plastic operation on the intestines; (5) *enteropexy*—operative fixation of a part of the intestine; (6) *enterectomy*—

Fig. 862.—Waugh's operation for prolapse of the ascending colon: Line of peritoneal incision.

resection or removal of a part of the intestine; (7) *entero-anastomosis*—operative union of intestine; (8) *intestinal elimination* or *exclusion*—a loop of bowel is diverted from the intestinal stream, without being detached from the body.

Enteropexy or colopexy is used for prolapsed rectum, colon, or cecum mobile. Enterostomy, duodenostomy, jejunostomy, ileostomy, colostomy may be done by Witzel's method with a technic similar to that for gastrostomy.

In the Maydl method of jejunostomy the jejunum is divided 20 cm. below the duodenum, and the end of the upper section implanted in the side of the lower

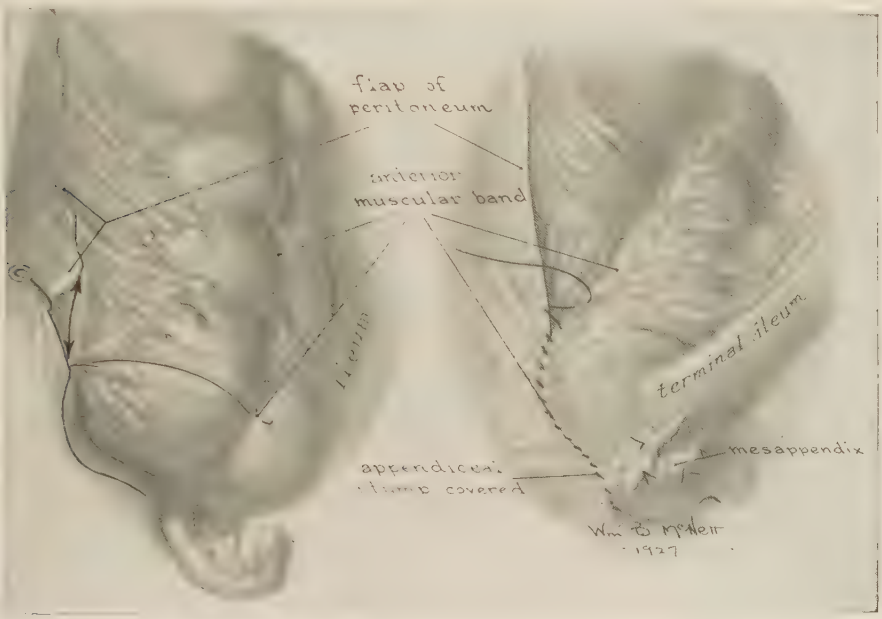


Fig. 863.—Waugh's operation (cecopexy, colopexy) for cecum mobile and ptosis of the ascending colon. The peritoneum is incised lateral to the cecum and ascending colon, and a subperitoneal pocket formed into which the cecum and adjacent colon are partially introduced, the lateral peritoneal edge being sutured to the anterior tænia of the colon. The appendix is usually removed.

section, 20 to 30 cm. below the point of division. The distal end is brought out through the abdominal wall, forming an opening upon the skin.

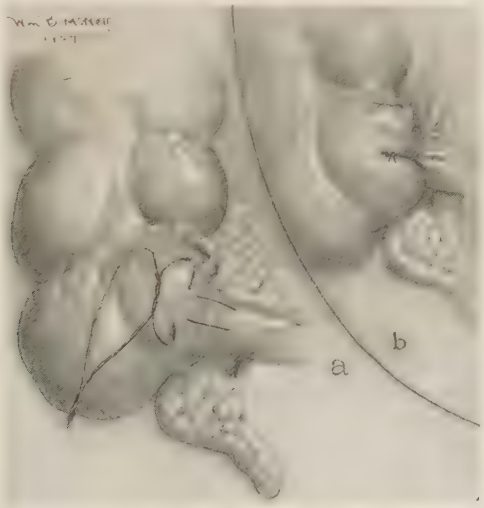


Fig. 864.—Kellogg's operation for incompetent ileocecal valve: *a*, Suture introduced; *b*, suture tied.

Colostomy usually is *cecal* or *sigmoid*. According to the location of the new opening, it is inguinal, lumbar, or ventral. A lumbar colostomy is less accessible and more difficult to keep clean, but may be performed without opening the peritoneum by using the extraperitoneal portion of the descending colon.

Appendicostomy (Weir's Operation). The appendix is delivered through a short McBurney incision, and sutured in the wound without division of the meso-appendix. The tip of the appendix is then excised, and a small catheter introduced through the lumen into the cecum, and tied in. Because of the small size of the appendix, a cecostomy is often preferable. The operation enables the colon to be effectively irrigated in chronic forms of colitis and tropical dysentery, and has been used for epilepsy with obstipation by Laplace.

Anastomotic Operation on the Alimentary Canal. -*Historical:* In the development of methods of intestinal and gastric anastomosis, mechanical aids to suture were considered desirable; these included the catgut rings of Abbe, the bone-plates of Senn, the decalcified bone-bobbin of Mayo-Robson, the inflatable rubber-cylinder of Halsted, the bobbin formed of raw potato or carrot, the button of Murphy, the segmented aluminum-ring of Harrington, the forceps of Laplace, and other devices. With experience in the methods of simple suture, these accessories have been found unnecessary and often harmful.

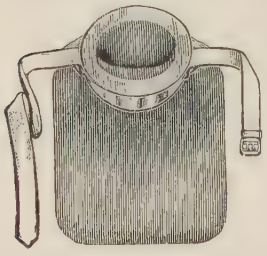


Fig. 865.—Brick's colostomy bag and belt.

Entero=anastomosis (*suture anastomosis of the intestine*) may be *iso-peristaltic*, where the direction of the intestinal flow is not turned, or *antiperistaltic*, where the anastomosis reverses the direction of the intestinal current. The union between two loops of intestine may be: (1) *End-to-end* or circular; (2) *side-to-side;* (3) *end-to-side;* (4) *side-to-end.* Two or three rows of interrupted or continuous sutures are used.

Indications.—In intestinal obstruction, tumors, strictures, strangulation of the intestine, tuberculosis, extensive ulceration, and for intestinal exclusion.

A. Intestinal Anastomosis.—Axial anastomosis is preferable to end-to-side or lateral anastomosis; isoperistaltic to antiperistaltic union.

Aseptic resection of the intestine depends upon the division of the bowel by the actual cautery, after bulk heading or closing the lumen of the bowel adjacent to the points of division by clamp ligature or snare. The closed bulk-headed ends of the gut are then brought together and united without opening the lumen, after which the lumen is re-established by: (1) A knife introduced through the rectum to divide the double partition (Halsted, 1922). (2) Minute ligature guillotines which divide the two purse-string sutures that occlude the ends of the bowel, after the external anastomosing sutures are inserted. (3) A looped purse-string suture is used which is released. (4) A wire snare is used to constrict and occlude the ends (Highsmith), and after the external sutures are in place the wire constriction is slipped out. (5) Ligation and resection of mesocolon. Circular incision around intestine at the points for division to the submucosa, the serosa and muscular layer being reflected and the mucosa doubly clamped and divided between small narrow clamps by the cautery. The clamps are now apposed and the mucosa, muscularis, and serosa united in layers, the clamps being slipped off just before the last suture is tied (Shoemaker). After these end-to-end anastomotic operations the lumen is opened by manipulating the bowel or by pulling upon traction sutures which have previously been introduced. It is to be remembered that bacteria may be forced through the walls when the bowel is crushed, and that the walls of obstructed intestine are permeable to bacteria.

1. *Aseptic intestinal anastomosis* by *basting-stitch method* (Parker-Kerr, 1907) may be used for axial or lateral anastomosis:

a. The loop of bowel to be removed is mobilized, and the mesentery resected with ligation of all vessels.

b. The segment of bowel is removed by the cautery between clamps.

c. A continuous basting stitch of fine silk without knots is introduced by a Cushing continuous suture, crossing over the blades of the closed clamp. As the clamp is removed, the ends of the

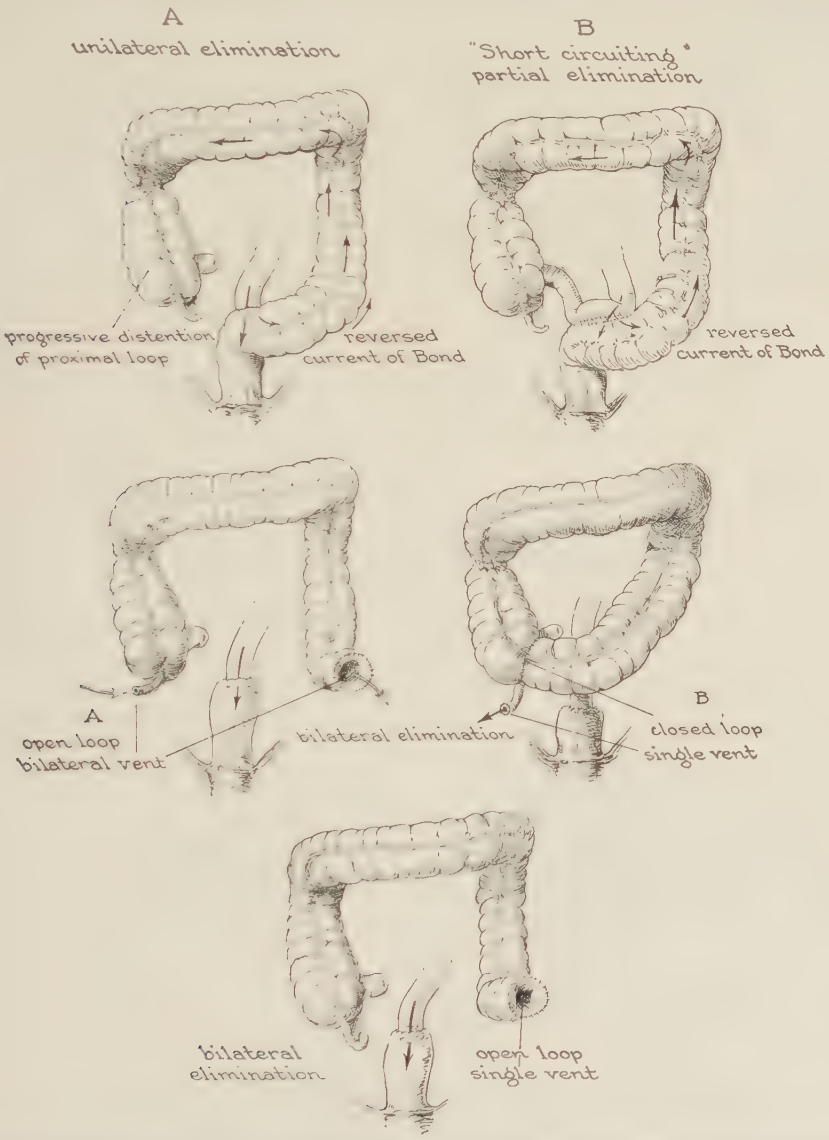


Fig. 866.—Methods of intestinal elimination: unilateral, bilateral, partial, and complete, with closed or open loop and a unilateral or bilateral vent to the anterior abdominal wall. The danger of distention and stagnation from the reversed intestinal currents of Bond is shown in *A* and *B*.

basting stitch are pulled taut, inverting and closing the bowel and leaving a smooth peritoneal coat. The other section of gut is treated in the same way.

d. The closed ends of the bowel are brought into apposition, and united in the usual fashion

by two layers of seroserous suture. Before the final stitch is tied, the two basting stitches are withdrawn, and the stoma finally is opened by manipulation between the thumb and forefinger.

For anastomosis with the side of the bowel, a lateral fold of the desired size and position is isolated by crushing forceps, and the projecting portion of the fold removed by the cautery. Basting stitches are then applied, and the anastomosis made as previously described.

2. *Aseptic Anastomosis by the Guillotine Method* (Fraser and Dott, 1924).—a. The bowel is isolated, the mesentery resected and ligated, and the loop of bowel removed between clamps by the cautery as usual. A ligature of fine catgut, threaded into the ligature guillotine, is introduced as a seromuscular suture, back of each clamp. This is firmly tied with inversion of the cauterized ends of intestines.

b. The closed ends are now approximated by two rows of interrupted or continuous sutures, after which the occluding purse-string sutures are removed, by cutting the loops of thread with the guillotine and withdrawing them.

Anastomosis may also be made, after crushing and dividing the bowel between clamps, by applying the narrow-bladed O'Hara forceps or the three-bladed Rankin forceps (1928) and making the anastomosis over the apposed forceps, the forceps being removed as the suture is completed.

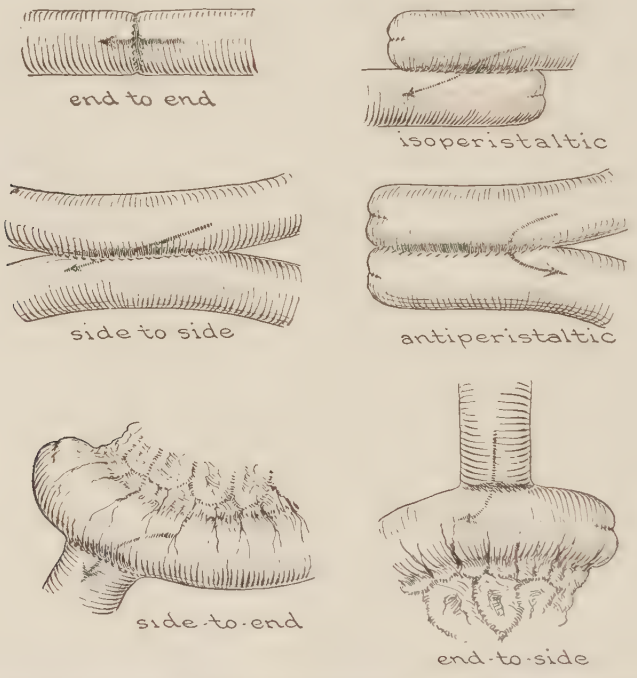


Fig. 867.—Methods of intestinal anastomosis—end-to-end, side-to-side, isoperistaltic, antiperistaltic, side-to-end, end-to-side.

B. Enterectomy in stages (*Mikulicz's operation*) avoids peritoneal infection in resection of the intestine, and is largely used for resections of the colon. An incision with or without muscle-splitting is made over the diseased loop of bowel, usually in the left lower quadrant. The steps of the operation are:

1. *Delivery of section of intestine* to be resected, with tumor, diverticulum, or other diseased tissue, including the affected mesentery and lymphatic glands. The intra-abdominal arms of the intestinal loop are approximated by a seroserous suture. The peritoneum and skin are closed about projecting bowel. If a vent is necessary, a tube is immediately fastened in the loop by a purse-string suture.

2. *Resection of protruding loop* with the diseased tissues by cautery or knife, usually after adhesions have formed, in from two to four days after the first operation.

3. *Conversion of artificial anus* into fecal fistula, by the application of *Dupuytren's clamp* or other crushing forceps (*Mikulicz's kentrotribe*) to the intra-abdominal projections of the loop of intestine. The clamp cuts through the partitions between the arms of the loop, loosens, and comes away in four to six days.

4. *Closure of fecal fistula* by an extraperitoneal operation some weeks or months later, if it does not spontaneously close.

For a long, narrow intestinal fistula, the tract is asepticized by cautiously swabbing with saturated zinc-chlorid solution (which should not enter the bowel), delineated by injecting a solution of methylene-blue, circumscribed by an elliptic incision, which is deepened without entering the fistula until the intestine is reached, where the fistulous tube is divided between clamps close to the intestine, by a cautery, and the stump inverted into the wall of the intestine, and closed by a purse-string suture as with an appendiceal stump.

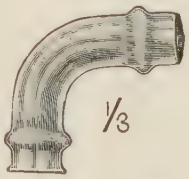


Fig. 868. — Paul-Mixter glass intestinal tube for enterostomy.

Elimination of Intestines.—The fecal current is shunted around a loop of intestine, to overcome obstruction, atony, dilatation, or other disease in the loop, or as the first stage in an intestinal resection.

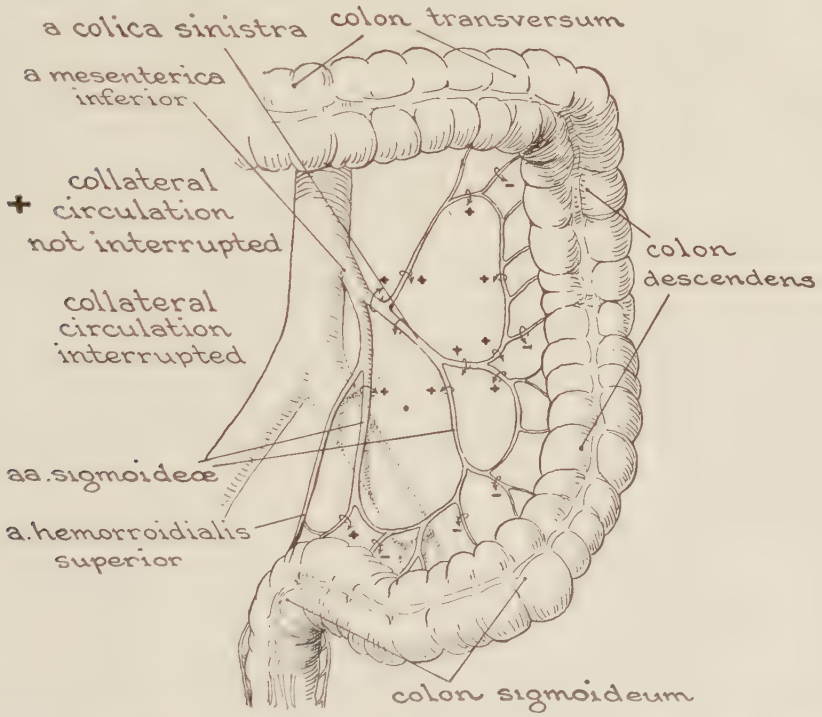


Fig. 869.—Collateral circulation of the sigmoid colon in relation to resection of the sigmoid.

I. **Partial Elimination**: The loop continues to communicate with the alimentary canal, there being either (1) closure by suture of upper end of the loop, or (2) closure of lower end of the loop.

II. **Total Elimination**: The loop no longer communicates with the alimentary tract, and is treated by: (1) Suture of both ends; (2) suture of one end, the other

end forming a fistula; (3) both ends open and forming fistulæ; (4) closure of both ends with separate fistula. Partial elimination is often unsatisfactory from the action of the reversed current of Bond, returning intestinal contents to the loop. Following ileosigmoidostomy, for example, the hemi-excluded colon becomes greatly distended from anastalsis.

Complete elimination with closure of both ends may be followed by distention and rupture of the eliminated loop, so a vent should always be provided.

Cecostomy may be used to cause a unilateral elimination of the colon. Phillip's Method (1927): (1) McBurney's incision with some muscle division; (2) 5 cm. of the head of cecum and base of appendix are brought through the wound, and sutured to the peritoneum, skin, and muscle; (3) a clamp is applied, and the head of cecum excised distal to clamp. After the clamp is removed on the second day, the ileocecal valve protrudes into the wound, completely eliminating the colon from the fecal stream. To close, the cecum is dissected from the abdominal wall, and sutured and replaced in the abdomen, which is finally closed.

Enterectomy is indicated for tumor, stricture, gangrene, intussusception, perforation and extensive traumatic laceration, chronic intractable inflammation, stasis or dilatation of the intestine, fecal fistula, diverticulitis, ulcerations of the colon, and growths in the mesentery, removal of which jeopardizes the circulation of a section of the intestines.

Colectomy.—Physiologic Effects: (1) Intense postoperative thirst, which may necessitate hypodermoclysis; (2) possible immunity to toxic foods; (3) primary diarrhea of 10 to 15 watery stools daily. This gradually ceases after two to three weeks, as the terminal ileum absorbs more water. Later an increase in weight is frequent as relief from toxic symptoms occurs.

Maunsell's Operation for Intussusception.—An antimesenteric longitudinal incision is made through the intussuscipiens, and the telescoped portion pulled out of the opening, transfixed at its base with needles and cut away, the two protruding edges of intestine thus formed are whipped together by continuous or interrupted through-and-through sutures, after which the longitudinal incision is closed, and the line of anastonosis reinforced by additional serous sutures. The method is objectionable from the great danger of peritoneal contamination.

CHAPTER LI

THE VERMIFORM APPENDIX

Anomalies.—The vermiform appendix varies in size, shape, and position; usually about 10 cm. long, it varies from 1 to over 20 cm. in length. The appendix is relatively large at birth, and tends to undergo atrophy and obliteration after middle life. Absence of the appendix is exceedingly rare, except when produced by disease, as is also duplication of the appendix, reported by Young. The appendix is found at the tip of the cecum at the end of the anterior tæniæ coli. While usually occupying the lower right abdominal quadrant, from failure of rotation of the colon it may lie just below the liver, under the spleen, or in the left lower abdominal quadrant near the sigmoid. In *situs inversus* of the viscera the appendix is, of course, found in the left lower abdominal quadrant. It also is found in the true pelvis, in the sac of an inguinal, femoral, umbilical, or ventral hernia; and may become inverted, and strangulated by adhesions or by the ring of a hernial sac.

The appendix has a meso-appendix and usually lies free, but it also may be retrocecal or retroperitoneal. The tip of the appendix may point upward and to the right (NW); downward and to the right (SW); downward and to the left (SE); or directly upward (N)—retrocecal.

Appendititis may be *acute, subacute,* or *chronic.*

Acute inflammations involving the mucous lining of the appendix are: (1) *Catarrhal;* (2) *ulcerative;* or (3) *purulent.*

Acute inflammations involving the outer walls of the appendix are: (1) *Acute hyperplastic;* (2) *phlegmonous;* or (3) *gangrenous.* The condition may be aggravated by an obstruction of the mucous lumen—*obstructive appendicitis;* or characterized (as in the ulcerative, gangrenous, and phlegmonous forms) by a tendency to perforation—*perforative appendicitis.*

Chronic forms of appendicitis include: (1) *Chronic catarrhal;* (2) *chronic hyperplastic;* (3) *chronic purulent;* (4) *atrophic* or *obliterative,* which is normal in senility. Forms of chronic infection due to special organisms occur, such as (5) *tuberculous* and (6) *actinomycotic appendicitis.*

In chronic appendicitis there is found thickening of the outer walls of the organ, the presence of fecal concretions or foreign bodies, stenosis with retained mucus or pus, cyst formation or atrophic changes. The mucosa is usually thickened, with greatly enlarged lymphoid follicles and a round-cell infiltration of the muscular walls. Segments of the appendix may have been destroyed by previous inflammation, leaving the tip or other portion of the appendix disconnected from the colon and adherent to the peritoneum.

Chronic internal or *external sinuses* may exist.

Etiology.—1. *Age:* Fifty per cent. of the cases of appendicitis occur between the ages of five and twenty years. It is relatively infrequent before the age of five and after forty years. The appendix has a relatively large lumen in

childhood, giving better drainage, and has not had the duration of infection that occurs with later life, while after forty the appendix undergoes atrophy and obliteration.

Fig. 870.—Senile, atrophic, or obliterative appendicitis.

2. *Sex.*—Appendicitis is more frequent in males.

3. *Familial Influence.*—Appendicitis is often found in the majority of members of a single family; probably because they are exposed to the same environment and types of infection, or have common anatomic peculiarities favorable to the infection.

4. *Phylogenetic.*—The appendix is a vestigial organ, the function of which has largely or entirely disappeared. It is the remains of a large sac for the maceration of food, found in certain herbivora. As with other organs with a lost function, it is more subject to inflammation than active parts of the body.

5. *Anatomic.*—The appendix has a long, narrow lumen which is encroached upon by many lymphoid follicles, is surrounded by relatively thick muscular

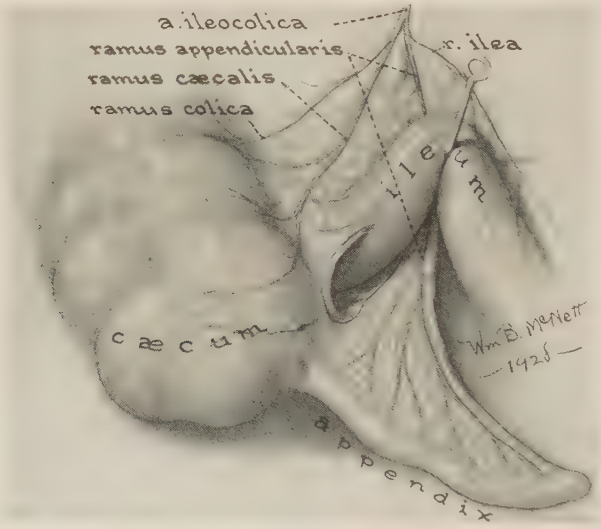


Fig. 871.—Blood-supply of the lower ileum, cecum, and appendix. Ligation of the ileocolic artery, as in the removal of a large mesenteric lymph-node, is followed by gangrene of the terminal part of the ileum, the appendix, cecum, and first part of the ascending colon.

and fibrous walls, and guarded by an imperfect valve, the valve of Gerlach. Foreign bodies entering the appendix tend to be retained. Swelling of the lymphoid follicles produces obstruction of the lumen, and interferes with nor-

mal drainage, favoring secondary stagnation, bacterial multiplication, and invasion. The appendix has a single arterial supply, the appendicular branch of the ileocolic artery, which is a terminal artery. Thrombosis or obstruction of the appendicular vessels causes gangrene of the organ.

6. *Race.*—Appendicitis is chiefly a disease of civilization and of the white race; it is less common in the negro, in the tropics, and in aborigines, possibly because in these the appendix usually has a larger lumen, better drainage, and less lymphoid hyperplasia.

7. *Infections* that produce general lymphoid hyperplasia, such as measles, scarlet fever, tonsillitis, influenza, typhoid fever, and enteritis, often precede appendicitis.

8. *Bacterial Infection.*—In order of frequency, the following bacteria are associated with appendicitis: (a) Bacillus coli communis; (b) Staphylococcus

Fig. 872.—The appendicular artery is an end artery and when obstructed gangrene of the appendix follows.

pyogenes aureus and albus; (c) streptococcus; (d) pneumococcus; (e) B. pyocyaneus; (f) B. tuberculosis; (g) Streptothrix actinomycosis.

A number of anaërobic organisms also have been isolated from inflamed appendices.

9. *Intestinal parasites*, especially the oxyuris, are often found in the appendix and may produce abrasions of the mucosa, opening the way for infection. Infection of the appendix occasionally is found in amebiasis, leishmaniasis, and ascariasis. Amebic and typhoid ulcers occur in the appendix.

10. *Exciting Causes.*—Foreign bodies and fecal concretions, usually having the shape of date-stones, are found in 38 per cent.; grape or other seeds, pins and other foreign bodies, in about $\frac{1}{2}$ per cent.; animal parasites, especially the Oxyuris vermicularis, in about 10 per cent. Traumatism from a blow or fall may excite a latent appendicitis into activity, as may also pelvic congestion. In women, attacks occasionally recur with the menstrual periods.

Chronic obstructive appendicitis usually is associated with single or multiple strictures, with secondary atrophy or distention and the formation of loculi or cysts. Aberrant masses of epithelium, including (rather rarely) islands of endo-

metrial tissue, may be found growing in the appendix at the ages of sixteen to eighteen years, and may be mistaken for carcinoma.

Symptoms of Acute Appendicitis.—In a typical attack the symptoms unfold in the following chronologic order, as emphasized by Murphy: (1) Tormina; (2) nausea; (3) localization at McBurney's point; (4) fever.

1. *Tormina.* This is generalized or referred to the navel and epigastrium, is colicky in nature, and reaches its acme in about four hours, when it may gradually subside. The patient may continue at work, but usually goes to bed to obtain relief. Initial violent pain, that prevents movement and that is so severe as to require an opiate, suggests rupture of the appendix, but this rarely occurs without previous symptoms. Sudden subsidence of the pain within the first thirty-six hours may be due to the evacuation of infected material from the appendix into the colon, with recovery, or the development of gangrene of the appendix. Severe pain after primary subsidence is ominous, and suggests serious complication, usually peritoneal involvement. Secondary pain occurring after the first thirty-six hours as a rule is not colicky in type, and is due to peritonitis.

Fig. 873.—Acute purulent appendicitis, the appendix is red, injected, and distended by pus.

2. *Nausea*, which may be followed by vomiting, particularly if food or liquid is given by mouth, occurs in from two to four hours after the onset of the pain, and is an ileopyloric reflex from the distended and inflamed appendix. Usually only one or two efforts at emesis occur, after which the nausea subsides. With a badly inflamed appendix in a retrocecal or pelvic location, there is persistent nausea with repeated attacks of vomiting, especially every time that any liquid is taken by mouth. Anorexia is usual throughout the attack. Secondary nausea and recurrent persistent vomiting suggest peritoneal involvement and peritonitis. As the peritonitis progresses the vomitus becomes greenish black, or the fetid yellowish or grayish liquid of intestinal origin. In the final stages peritoneal vomiting occurs, being sudden, without warning, and often projectile in type.

3. *Tenderness.*—At first is diffuse and not marked, but in four to six hours becomes definite and localized at *McBurney's point*, which is 5 cm. from the right anterior superior iliac spine on a line to the navel. Cutaneous hyperesthesia of the skin of the right lumbar region and lower abdomen, supplied by the eleventh intercostal nerve, is at times associated. If the appendix lies in contact with the anterior abdominal wall, the tenderness may be superficial; with a deep-lying or retrocecal appendix, the tenderness may only be elicited on deep pressure. If the appendix is in the pelvis, there may be no abdominal tenderness, but fulness and sensitiveness is found by rectal or vaginal examination. With the rather rare, highly placed appendix, subhepatic tenderness

may be present; or if the cecum has not rotated or is transposed, the tenderness may be on the left half of the abdomen. Where the parietal peritoneum is irritated, there the overlying muscular abdominal wall is found in involuntary muscular contraction.

4. *Increased temperature* is the last symptom to appear, and develops in from four to twenty-four hours after the onset of the pain. As a rule, the temperature varies from 99° to 102° F., and is not high in acute appendicitis. With a retrocecal or extraperitoneal appendix, a higher earlier temperature may be present; and in fulminating cases, a temperature between 104° to 105° F. develops in eight to twelve hours after the onset of pain, from extraperitoneal invasion. The more acute the infection, the earlier the temperature; the milder the infection, the later does the temperature appear. A sudden drop in temperature suggests gangrene, perforation, or the evacuation of the appendix into the cecum. Rarely, no increase in temperature is found despite the presence of pus in the appendix, or a small or large walled-off

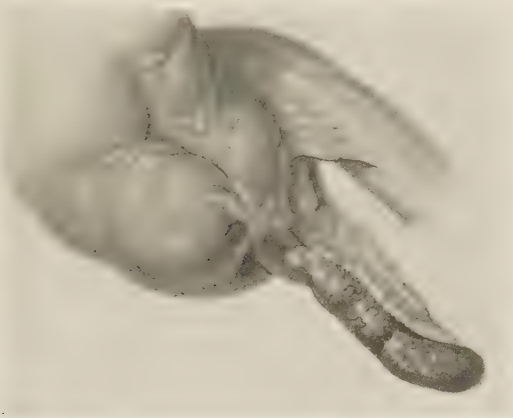


Fig. 874.—Gangrenous appendicitis, early stage involving the terminal third of the appendix.

Fig. 875.—Acute appendicitis from stricture with gangrene of the terminal third.

intraperitoneal abscess. This may occur in young patients with good resisting power, as well as in the asthenic and aged who show little reaction to infection.

A chill is not a symptom of appendicitis, but suggests thoracic or intravascular infection, particularly pneumonia, pleuritis, or pylephlebitis. In pylephlebitis, there are recurrent chills, sweats, with high fever, followed by an enlarging and sensitive liver. Sudden increase in temperature during the course of appendicitis suggests spread of the infection to the peritoneum or other tissues. A gradual reduction in temperature indicates localization of the infection and the formation of circumscribing adhesions, or a reduction in the pressure from the inflammatory products. A remission, with a later elevation of 2° or 3° F., evidences infection of a new area, and not infrequently follows the too early use of food or laxatives, or the premature removal of drains. It is to be

remembered that a temperature of 99° F. may not be exceeded despite gangrene, perforation of the appendix, abscess formation, or extensive peritonitis.

5. *Obstipation* and *ileus*, with vomiting, absence of peristalsis, and inability to expel gas or fecal material by tube or enema, indicate secondary local or diffuse peritonitis. In the rare pneumococcic or streptococcic forms of peritonitis, a watery diarrhea often occurs.

6. *Leukocytosis* of from 9000 to 18,000 usually appears early, and is characterized by a relatively high proportion of polymorphonuclear leukocytes (70 to 85 per cent.). Leukocytosis is the reaction to absorption and, if absorption is prevented by local barriers or if the patient has little reactive power, leukocytosis may be absent despite a severe local infection. In the asthenic patient, leukopenia expresses the lowered resistance to the infection.

7. *Tachycardia.*—An increase of the pulse rate to 90, 120 or more is a more reliable evidence of the infection than is the temperature. Persistence of the tachycardia with remission of other symptoms indicates gangrene of the appendix; a persistence of a pulse rate above 120 after treatment or operation is ominous.

8. *Local Symptoms.*—Reflex muscular rigidity or mass at McBurney's point, over the area of the appendix, is in direct proportion to the intensity and the area of the underlying peritonitis. A diffuse board-like rigidity indicates a generalized peritonitis. A corresponding superficial hyperesthesia elicited by pinching a raised fold of the skin, while occasionally present, is less valuable in the diagnosis than rigidity.

In subacute or chronic inflammation of the appendix, a localized area of slight rigidity (increased resistance) of the overlying abdominal muscles, felt only by very light palpation, may continue for weeks or months and is of great diagnostic value.

9. *Position.*—In acute septic appendicitis the patient lies upon his back, with the thighs elevated and the knees flexed. During the period of peritoneal invasion, and before localization has occurred, the patient lies quietly, avoiding movement, pressure upon the abdomen, and abdominal respiration. If localization has occurred, even in the presence of an abscess, the patient may continue to walk about and even attempt to work.

10. *Lymphadenopathy.*—Enlargement and tenderness of the right inguinal lymph-nodes are occasionally found.

11. *Contact inflammation* may give rise to vesical symptoms, such as dysuria, pollakiuria, or hematuria, from contact of the inflamed appendix with the bladder or ureter. This is not infrequently seen in children, or when the appendix is in the pelvis. Rectal tenesmus is less common than vesical tenesmus.

12. *Pain on Contraction of the Right Iliopsoas.*—On raising the right knee, especially while steady pressure is made over McBurney's point, pain is produced, particularly if the appendix is posterior or retrocecal. Sudden release of pressure made over McBurney's point causes pain. Distention of the colon by gas or liquid through a rectal tube may also produce pain in the region of the appendix.

Pelvic Examination.—If the appendix is in the pelvis, no mass or rigidity may be felt over the abdomen; the fulness, mass, and tenderness being found by the finger introduced into the rectum or vagina.

Epigastric pain and persistent nausea and vomiting, with slightly lower abdominal symptoms, suggest a pelvic or retrocecal position of the appendix.

Latent Period.—Six to twelve hours after the beginning of acute appendicitis there is often a cessation of pain, reduction of rigidity, and drop in temperature, from gangrene of the appendix or discharge of inflammatory products into the cecum. The latent period is followed later by evidence of peritonitis or by recovery, and has led to many fatal delays in operating for appendicitis. A lull in symptoms should always be considered ominous; frequently it is seen immediately after the patient has been brought to the hospital.

Symptoms of Special Forms of Acute Appendicitis.—1. *Gangrenous Appendicitis:* The attack begins as usual except that with the onset of gangrene, relief from pain, fall in temperature, and disappearance of rigidity may occur; the pulse rate continuing rather high, and the facial expression being one of sepsis.

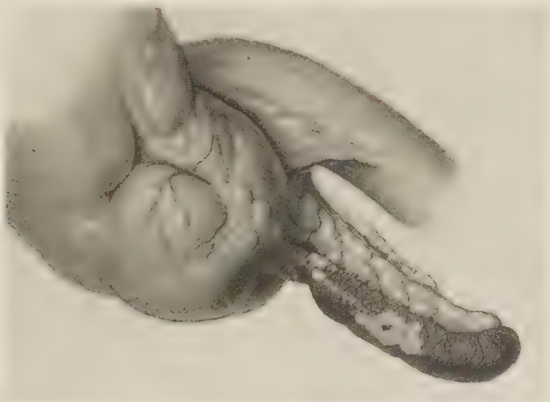


Fig. 876.—Gangrenous appendicitis with perforation surrounded by plastic lymph from peritonitis.

The lull in symptoms is followed after a few hours by a return of pain, rigidity, vomiting, and meteorism.

2. *Acute Perforative Appendicitis.*—The degree of pain varies with the amount of leakage and the size of the opening. If a laxative has been given, and the perforation lies close to the cecum, the symptoms may be fulminant. Occurring after symptoms indicating a mild subacute or acute appendicitis, an agonizing pain quickly localizing around McBurney's point, with marked rigidity and signs of ileus, is suggestive of perforation and leakage.

3. *Phlegmonous Appendicitis.*—*Appendiceal Abscess:* A mass, tending to rapidly increase in size, forms and is palpable through the abdominal wall, rectum, or vagina. Usually there is generalized abdominal tormina, ileus, and localized rigidity of the overlying abdominal wall. The mass consists largely of great omentum and bowel, adherent about the appendix. *Localized periappendiceal abscess* is common. The general and peritoneal symptoms subside as a tender firm mass forms in the lower right abdominal quadrant.

Alarming symptoms include sudden cessation of pain, rapid increase in or continued high pulse rate, recurrence of vomiting with black or intestinal

vomitus, absence of peristaltic sounds, meteorism, ileus or diarrhea, delirium, mania, general abdominal rigidity, and other signs of generalized peritonitis. Recurrent chills, fever, and sweats suggest pylephlebitis. Especially ominous is cyanosis of the fingers and toes, cold clammy skin and high rectal temperature, which, with collapse, occur from a secondary hematogenous infection.

Complications.— The danger of appendicitis lies in its complications.

1. *Peritonitis* is the usual complication and may be local or diffuse.

a. Localized Peritonitis: If from the onset the patient remains quiet in bed, and takes no food, laxative, or enema to stimulate peristalsis, the inflamed appendix, as a rule, becomes surrounded by adherent great omentum and adjacent coils of intestines, and a local or walled-off abscess forms, containing from a few drops to a liter or more of pus. Concretions or foreign bodies from the lumen of the appendix often enter the abscess cavity, and the appendix frequently sloughs off into the cavity. The abscess, if not opened, may spontaneously evacuate into the intestine, through the skin, into the bladder, ureter, pelvis of the kidney, through the diaphragm into the pleura, lungs, or bronchi, or into other adjacent hollow viscera. Rarely, the necrotic appendix is passed by stool, with recovery. Spontaneous evacuation into the intestine with recovery is too uncertain and unusual to be awaited or expected.

b. Diffuse peritonitis occurs if the inflammatory process is not localized, the infection passing into the pelvis, into the right renal fossa, and to other portions of the abdominal cavity. Despite a wide-spread diffuse peritonitis, if the patient is kept at complete rest with restriction of peristaltic movement, much of the pus may be absorbed, the diffuse process arrested and, if there is no continued leakage, localization of the peritonitis may take place. The localization occurs around the perforated or gangrenous appendix, or other necrotic tissue or foreign bodies, with a resulting abscess that follows the course of a primary localized peritonitis.

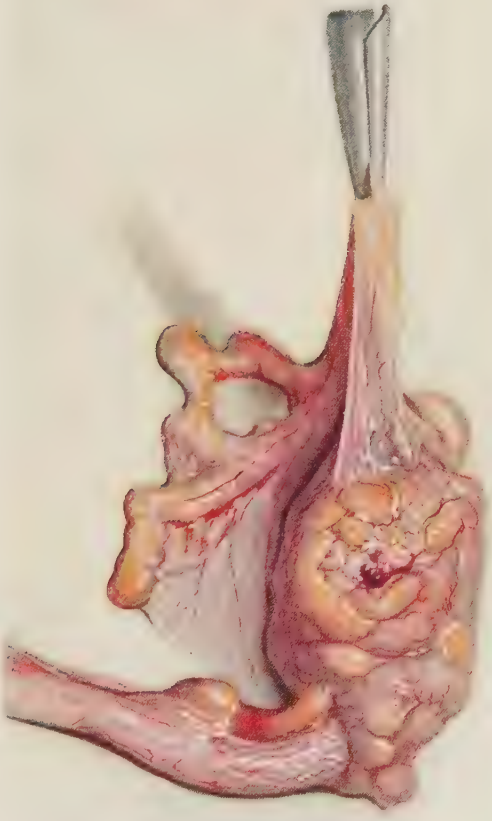
Fresh peritoneal pus is bactericidal, antitoxic, and protective; only old pus, with many dead cells, necrotic tissue or foreign bodies, requires removal by evacuation.

2. *Pylephlebitis.*—In this, septic thrombi form in the portal vessels of the meso-appendix, spread to the larger portal vessels, break down with pus formation so that the portal vessels may be filled with pus instead of blood. The infected thrombi and pus are carried to the liver, with recurrent chills, sweats, fever, and multiple hepatic abscesses.

Clinical Picture.—A young man with or without previous dietetic indiscretion is suddenly taken during the night or day with severe generalized abdominal colic, which is soon followed by nausea; in three or four hours the general colic disappears, and pain and tenderness are found to have localized in the lower right abdominal quadrant. Shortly after this, a temperature of from 99° to 102° F. is found. There is constipation, the patient lies on his back with his knees drawn up, the pulse rate is slightly increased, the respirations are slow, costal in type rather than abdominal, and the pain is rarely severe enough to require an opiate unless there is peritoneal involvement.

Diagnosis.—*Roentgen examination* of the appendix is often of little value, and is only applicable in the subacute and chronic forms. Barium or bismuth

Acute gangrenous appendicitis: Twelve hours' duration.



Acute perforative appendicitis: Tip of appendix containing perforation enclosed in omental adhesions.

may be given by mouth for twenty-four to forty-eight hours with the food, or may be injected by the rectum: (a) The appendix is visualized and, on manipulation under the fluoroscope, found to be tender or thickened. This suggests appendicitis. (b) A concretion, loculus, or stricture is demonstrable, indicating disease of the appendix. (c) The appendix is visualized, and found, under the fluoroscope, to be fixed and immovable from adhesions, or from a retroperitoneal or retrocecal position. (d) The appendix is not visualized on account of obstruction or kink, or the normal closure of the valve of Gerlach, in which case the appendix may or may not be diseased.

Differential Diagnosis. 1. Renal or ureteral colic is characterized by pain in the loin that radiates to the bladder and testicle and often follows exertion. It is sudden in onset, and associated with percussion tenderness over the loin, and with urinary symptoms, as vesical tenesmus, anuria, hematuria, pyuria, and later the passage of gravel. Fever is absent, and the calculus is shown on Roentgen examination. In appendicitis the diffuse colic precedes the localization of pain, and the tenderness is localized and does not radiate along the ureter. The possibility of hematuria and vesical tenesmus in appendicitis is to be remembered, and also that reflex ileus with abdominal distention and obstipation occurs in renal colic.

2. Dietl's crisis is due to the kinking of the ureter from movement of a loose kidney, and the symptoms are those of an acute renal colic. The displaced kidney may be felt, and the symptoms are relieved by posture and replacing the kidney.

3. Biliary colic chiefly occurs in obese middle-aged women, with pain in the epigastrium or upper right quadrant. The paroxysms are of abrupt onset, severe (usually requiring an opiate), transient, occur at night, and begin with a sense of pressure and pain and not a general abdominal tormina. The pain radiates to the back and under the right shoulder, and the patient tries to obtain relief by inducing vomiting.

4. Cholecystitis with marked enlargement of the gall-bladder. The lower end of the inflamed gall-bladder may come in contact with the abdominal wall near McBurney's point, producing a tender resistant area with overlying reflex rigidity of the abdominal muscles. A careful examination shows that the mass passes up under the margin of the ribs. The primary diffuse abdominal colic is absent, and a history of preceding biliary colic and qualitative dyspepsia is usual.

5. Perforating peptic ulcer. This is characterized by pain in the upper right quadrant and the epigastrium, rapidly spreading down to the lower right quadrant, with shock and increasing dulness in the flanks, due to free fluid in the abdominal cavity. The peritoneum of the lower right quadrant may, from the gravitation of gastric or intestinal contents, suffer the greatest irritation, so that the secondary tenderness and reflex rigidity is at McBurney's point. The pain is more sudden and more intense than in appendicitis, is not preceded by the generalized colic, and there may be an antecedent history of "food-ease" and "hunger-pain."

6. Salpingitis is characterized by initial sharp pain in the pelvis and lower abdomen with bilateral tenderness at Morris' points, there are no preceding

tormina, the fallopian tubes may or may not be palpable but are tender, there is purulent vaginal discharge or other evidence of pelvic infection, and a history of a preceding gonorrhea, endometritis, abortion, or miscarriage. Vesical and rectal tenesmus are commonly associated.

7. Acute thoracic disease. Pneumonia and pleurisy produce reflex abdominal pain with tenderness, rigidity and fever, that repeatedly has been mistaken for appendicitis. The onset, however, is by chill and fever, followed by abdominal rigidity and tenderness, which as a rule is generalized or more marked on the side corresponding to the lung and pleura involved. The temperature, ranging from 102° to 105° F., is higher or occurs earlier than in appendicitis. The initial tormina of appendicitis are absent, there is dyspnea and usually an expiratory grunt, and râles and friction-sounds are heard over one lung. The diagnosis may be difficult, especially in children.

8. Typhoid fever begins with malaise and fever, not tormina and nausea. In the early stages it is characterized by tenderness, slight rigidity and fulness in the region of the appendix, associated with daily step-like elevations of temperature and other prodromal symptoms. The pain and local tenderness develop after an increasing illness of from four to ten days, instead of after a few hours.

9. Strangulated hernia gives symptoms of ileus, is of sudden onset, with little or no local tenderness or rigidity, but with a small or large, tense hernial mass.

Prognosis.—Appendicitis is more dangerous in infancy and in old age, or in patients debilitated by diabetes, Bright's disease, or intemperance. Septic forms of appendicitis are especially dangerous in the later months of pregnancy, owing to the mechanical impediment from the uterus to operation and drainage. When the abdominal distention preponderates over abdominal rigidity, the peritonitis has often reached an advanced and serious stage.

Appendiceal colic subsides without perforation, gangrene, or abscess in about 86 per cent. of the cases. Recurrent attacks occur in over three-fourths of the patients. Serious complication may develop with any attack, and the lightness of previous attacks does not indicate the severity of those to follow. The lowest mortality is obtained by prompt operative treatment. In uncomplicated subacute and chronic cases this is less than 0.1 per cent. The danger of acute appendicitis lies chiefly in the use of food, laxatives, and ambulant treatment and delay as to operation. Without peritonitis the mortality of operation during acute appendicitis is ½ per cent. or less. In acute appendicitis of all types, with operation during the first twenty-four hours, the mortality is 2 per cent. or less. In purulent localized appendicitis, the mortality is 3 per cent. In diffuse peritonitis early stage the mortality is under 7 per cent. or 16 per cent. in the later stages if a quick non-traumatizing operation is done with little exposure or handling; or 40 to 80 per cent. or higher in the later stages if the operator explores, eviscerates, irrigates, mops, sponges, and exposes and traumatizes the peritoneum. The mortality of appendicitis with diffuse peritonitis under the Ochsner treatment is 16 per cent. (Ashhurst), with localized peritonitis 2 to 4 per cent.

Terminations.—Acute appendicitis may result in:

1. *As to the Appendix.*—(a) Restitution by escape of the infectious material into the cecum; (b) cicatrization with stenosis, or stricture and obliteration with loculi or cyst formation; (c) adhesions, with flexion or torsion of the appendix; (d) permanent appendiceal fistula, external or internal; (e) circumscribed appendiceal abscess; (f) complete disappearance of the appendix as a result of gangrene; the organ may be passed by bowel or through a sinus.

2. *As to the Abdomen.*—(a) Circumscribed inflammation about the appendix, the meso-appendix, and adjacent peritoneum, without the formation of pus but with adhesions; (b) local or multiple abscesses in the peritoneal cavity, in the pelvis, about the kidney, in the subdiaphragmatic region, or elsewhere; (c) diffuse peritonitis—serofibrinous, seropurulent, or purulent; (d) iliac thrombophlebitis, with obstruction of the venous system, absorption or embolism, with or without secondary abscesses and pyemia; or (e) septic thrombosis of the portal veins, with pylephlebitis and fatal hepatic abscesses.

3. *As to Extension.*—An appendiceal abscess may evacuate: (a) By producing necrosis of the intestinal wall, emptying into the cecum or other portion of the alimentary canal; (b) by burrowing to the surface directly through the anterior abdominal wall; (c) by following along the iliopsoas muscle into the groin, like a psoas abscess; or to the loin, the abscess evacuating in the lumbar region; (d) by forming a subphrenic abscess; (e) by emptying into the ureter, kidney, or bladder; the bladder offering greater resistance to intraperitoneal pus than does the intestinal wall; (f) by lymphangitis, with transmission of the infection to distant tissues without perforation; (g) the abscess may remain circumscribed for months, and finally rupture into the free peritoneal cavity and a general or circumscribed peritonitis result; or it may lose its virulence, and remain as a cold abscess. The quantity of pus in the peritoneal cavity is no indication of the danger of the peritonitis.

Subphrenic abscess and perinephritic abscesses frequently result from purulent appendicitis.

4. *Hemorrhage.*—The perforation of a large or small blood-vessel may cause a hemoperitoneum, a large peritoneal clot, intestinal hemorrhage and, if the vessel is large, exsanguination and death.

Association of blood and blood-clot in the peritoneum with infection is very serious. The bacteria growing in the clot acquire virulence and then swarm out, often with a fatal peritonitis, a general septicemia, or septicopyemia. An infection limited purely to the peritoneum is rarely fatal; the patient is overwhelmed by the extension of the infection to the extraperitoneal tissues and to the blood. A general bacteremia and septic involvement of the joints, pleura, pericardium, heart, muscles, or other organs may occur.

5. *Local Complications.*—The spread of the infection to contiguous organs, leads to inflammation of the bladder, uterus, rectum, kidney, and nerves. An intense persistent sciatica has followed irritation from an overlooked and chronically inflamed retrocecal appendix.

Symptoms of Chronic Appendicitis:

1. *Appendicular dyspepsia* usually is of the qualitative type. The distress occurs fifteen to twenty minutes after eating, especially of rich or indigestible foods, with a sense of weight, fulness, and burning in the epigastrium, and often

with sour, bitter eructations; the ileopyloric reflex causing pylorospasm, with gastric retention and acidity.

2. *Chronic enterocolitis* follows the discharge of septic products from the appendix into the colon. Recurrent attacks of diffuse abdominal colic in young persons are very suggestive of appendicitis. Attacks of diarrhea without evident cause, or due to slight provocation, such as warm weather and the ingestion of fruit, is often due to appendicitis. Noble's rule is that the appendix should be removed in all cases of chronic diarrhea for which careful examination shows no other cause.

3. *Toxic symptoms*—such as headache, myalgia, arthritis, neuritis, lumbago, sciatica, and the like—may result from the absorbed toxins in chronic appendicitis, or be due to the focal infection.

Fig. 877.—Chronic catarrhal appendicitis. Macroscopically the appendix appears nearly normal, there is slight injection, thickening of mucosa, and leukocytic infiltration in submucosa.

4. *Biliary disease* and *peptic ulcer* occur as a focal infection from a pre-existing appendicitis.

Treatment.—In appendicitis there is a tendency to recurrence of acute attacks, and to gangrene, perforation, and peritoneal infection. There is no successful medical treatment for appendicitis; therefore, it is desirable to remove the appendix as soon as possible after the diagnosis is made.

In chronic appendicitis the operation should be done promptly, for fear an acute attack and its complications may develop. In acute appendicitis the operation should be done immediately, to avoid dangerous complications such as perforation, gangrene, peritonitis. Waiting for a favorable interval has repeatedly resulted in a fatal complication. Delay for an interval operation, therefore, should never be practised. In chronic appendicitis operate within a few days, or as soon as the necessary arrangements can conveniently be made. In acute appendicitis operate immediately, and especially during the first twenty-four hours, before serious complications have developed.

1. Medical Treatment.—The preferred treatment of appendicitis is immediate operation. Medical treatment is used: (1) Pending the establishment of the diagnosis; (2) pending the acceptance of operation by the patient; (3) during the period that skilled operative services are not available; (4) while the condition of the patient renders the operation unduly hazardous.

In 96 per cent. of the cases of acute appendicitis localization of the infection occurs, if the patient is kept in bed and given absolutely nothing by mouth. Spreading or general peritonitis in appendicitis usually is due to lack of rest, and to the administration of laxatives and food.

The treatment prior to operation aims to arrest peristalsis, which causes leakage and diffusion of infection in the peritoneum, and prevents isolation and

localization of the diseased area by protective adhesions. It includes therefore: (a) Absolute rest in bed in the Fowler position. (b) Withholding of all liquid and food by mouth. If a heavy meal has been taken, it should be removed by lavage. (c) Avoidance of medicine, and especially laxatives by mouth. (d) Avoidance of enemas. While less harmful than laxatives or food by mouth, enemas stimulate peristalsis and should be avoided, except to empty the lower bowel. (e) Avoidance of opiates, until the diagnosis has been made and the plan of treatment decided. The sedation from opiates interferes with the diagnosis, and often leads to dangerous delay. Sufficient morphin or codein is therefore given, by hypodermic, only after the diagnosis is made, and when the comfort given the patient will not cause a dangerous delay in operating. (f) A partially filled ice-bag or hot-water bottle applied to the abdomen gives a degree of comfort. The skin should be watched and protected to prevent vesication and gangrene. (g) Liquids and food are given only by subcutaneous or intravenous infusion, until a safe degree of localization has occurred.

2. Operation in appendicitis is performed to remove the appendix, to provide drainage for an abscess or for peritoneal exudate, and to remove foreign bodies.

Fig. 878.—Chronic interstitial appendicitis. The walls are markedly thickened.

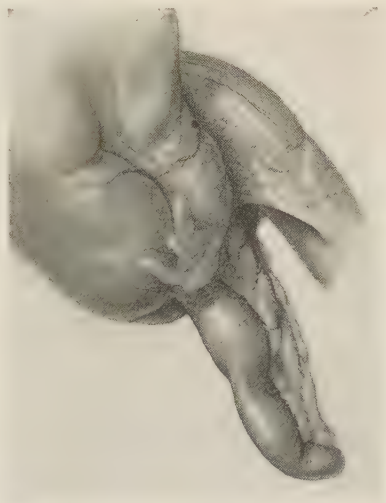


Fig. 879.—Chronic catarrhal appendicitis with dilatation and fecal concretions.

Delay in Operation: During an acute attack of appendicitis operation may be delayed if there is clear evidence of localization, as shown by a localized mass and limited rigidity, the general abdominal wall being flat, scaphoid and soft, the pulse and temperature showing a tendency to fall, vomiting being absent, and flatus escaping. In such a case the operation may be delayed for a few hours, until more convenient arrangements can be completed; thus, the operation may be deferred from the middle of the night until the following morning, when conditions for operation will be more satisfactory. When the patient is in great shock or collapse, being overwhelmed by the toxemia, operation may be deferred for a few hours with the hope that the patient's resistance may improve and some degree of localization occur, the Ochsner treatment being used in the meantime.

When there is very dangerous associated disease (such as acute pneumonia) that might exacerbate, the operation may be delayed. Where local facilities for expert surgical attention are not available, the operation may be delayed.

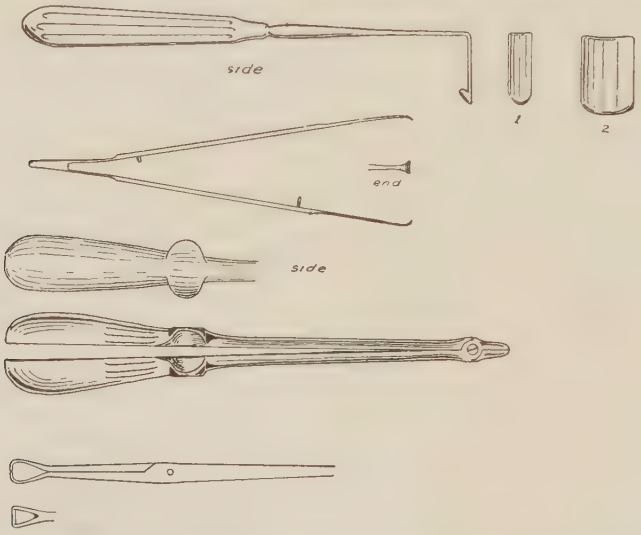


Fig. 880.—Retractors for a small appendiceal incision, with edges, to facilitate easy introduction without slipping. The thumb forceps are strong enough to hold, yet have teeth too fine to crush, puncture, or tear. The needle-holder, without distracting or time-absorbing springs and catches, releases the instant the hand relaxes. The viscera forceps hold the appendix or bowel without crushing.

In tropical diseases, amebiasis, and typnoid the patient snould be treated for the more general infection rather than the local involvement of the appen-

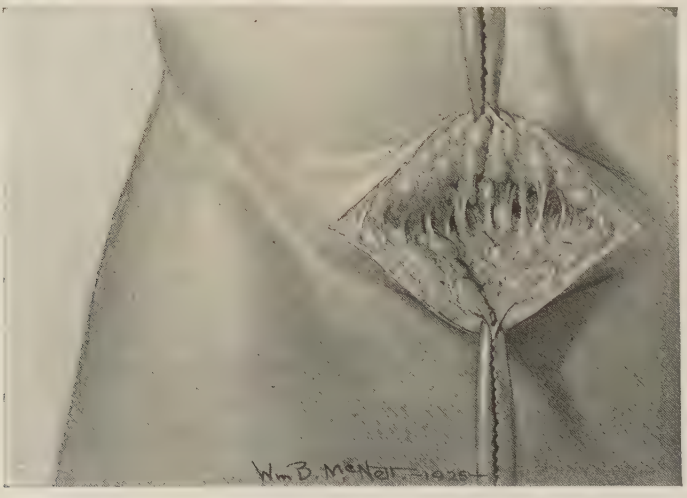


Fig. 881.—For the usual appendectomy, a 3 or 5 cm. transverse incision, starting 2 cm. medial to the anterior iliac spine, is sufficient. For satisfactory exposure through such a short incision, small retractors with a special edge to prevent slipping or injury, and with blades that are not curved, are desirable. The transverse incision being in the line of skin cleavage leaves an inconspicuous scar.

dix, and appendectomy should be delayed or resorted to only when the local condition endangers life.

Operative Treatment.—a. First Forty-eight Hours: In acute septic appendicitis, during the period of onset, or approximately the first forty-eight house, immediate operation is the preferred treatment. If there is definite evidence of localization, a few hours' delay is permissible.

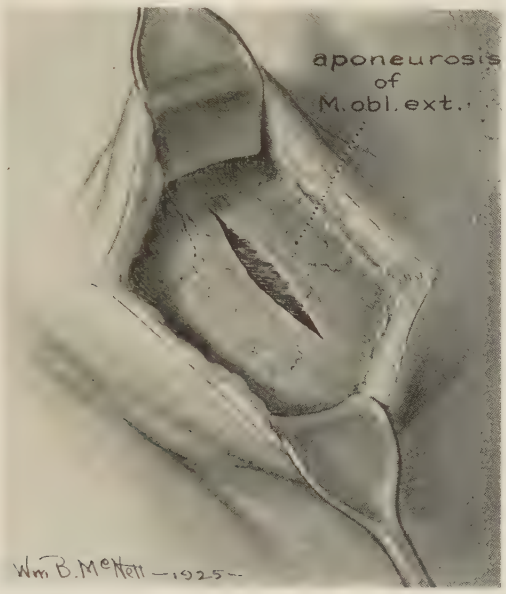


Fig. 882.—Appendectomy: Transverse skin incision. Aponeurosis of external oblique exposed and fibers split (McBurney's or gridiron incision).

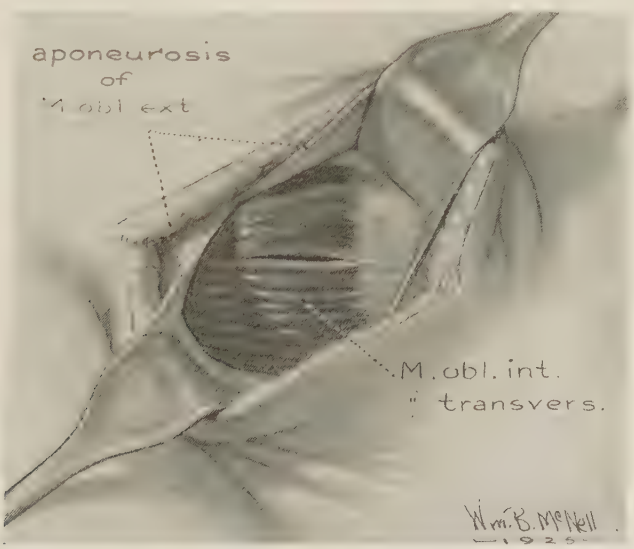


Fig. 883.—Appendectomy: External oblique retracted; internal oblique and transversalis exposed and divided in the direction of their fibers.

b. Second to Seventh Days: If localization has not occurred, this is the increasing inflammatory stage, during which an extensive intra-abdominal operation gives a high mortality. For patients seen in this period Ochsner advocated rest and delay for five days or more, or until safe localization of the infection had occurred.

Ochsner's Treatment.—Operate at once in all cases seen in the first forty-eight hours. If disease has lasted over forty-eight hours, especially if abdominal rigidity has been succeeded by marked distention, defer operation for five days or more until localization has occurred: (a) Empty

Fig. 884.—The McBurney or gridiron incision for appendectomy: 1, Skin and fascia divided and retracted, exposing the fibers of the external oblique; 2, the fibers of the external oblique split and retracted, exposing the internal oblique and transversalis muscles; 3, separation of the fibers of internal oblique and transversalis with exposure of preperitoneal fat; 4, peritoneum opened, exposing the cecum.

stomach by stomach-tube, and give no food, water, or medicine by mouth; (b) empty bowel and give nourishment by rectum; (c) continuous use of Fowler's position; (d) for severe pain or to quiet peristalsis, opiates are given by hypodermic injection.

With the Ochsner treatment used in the stage of general peritonitis about 10 per cent. of patients will fail to have localization, and will die; and with the deaths following the delayed operation, the total mortality will be about 16 per cent., which is much better than the 40 to 80 per cent. mortality following the

extensive operations formerly done in the increasing inflammatory stage. The skilled surgeon, who sufficiently limits his peritoneal exposure and traumatism, may obtain better results by: (a) Immediate operation ("NOW is the accepted

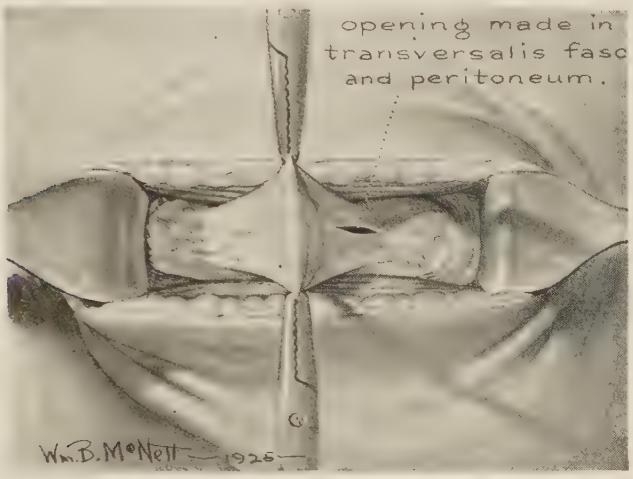


Fig. 885.—Appendectomy: Opening the peritoneum. To avoid injury to the underlying bowel, the peritoneum is first opened through the sloping peritoneal surface distant from the holding forceps.

time in appendicitis," J. B. Murphy)—small incision over the seat of trouble; arrest of intestinal leakage, without irrigation, sponging, exposure, handling of the abdominal contents, or loss of time; (b) relief of abdominal tension by a rub-

Fig. 886.—Purse-string suture with inversion of the base of the appendix. After this method hemorrhage in the cecum occurs in $\frac{1}{2}$ per cent. of the patients, unless care is taken to carefully occlude the vessels included with the appendiceal stump. Only simple ligation without cauterization is to be used if peritonitis is present.

ber drainage-tube passed to the bottom of the pelvis; (c) relief of intestinal tension, if necessary, by jejunostomy; (d) Fowler's position; (e) continuous hypodermoclysis with physiologic saline; (f) emptying of the stomach and keeping it absolutely empty until localization has occurred.

Operation.—1. **McBurney's or gridiron incision,** with transverse instead of the original oblique skin incision. The skin incision starts 2 cm. medial to the right anterior superior spine, running transversely or along the line of skin cleavage for 3 to 7 cm. The skin is retracted, the fibers of the external oblique exposed, split and retracted, exposing the muscular belly of the internal oblique and transversalis, the fibers of which run transversely. These fibers are likewise separated without division, exposing the peritoneum, which is also divided transversely.

Location of the Appendix.—The appendix is located by: (a) Sight; (b) palpation, the finger being carried to the brim of the right pelvis and swept from within outward under the cecum, catch-

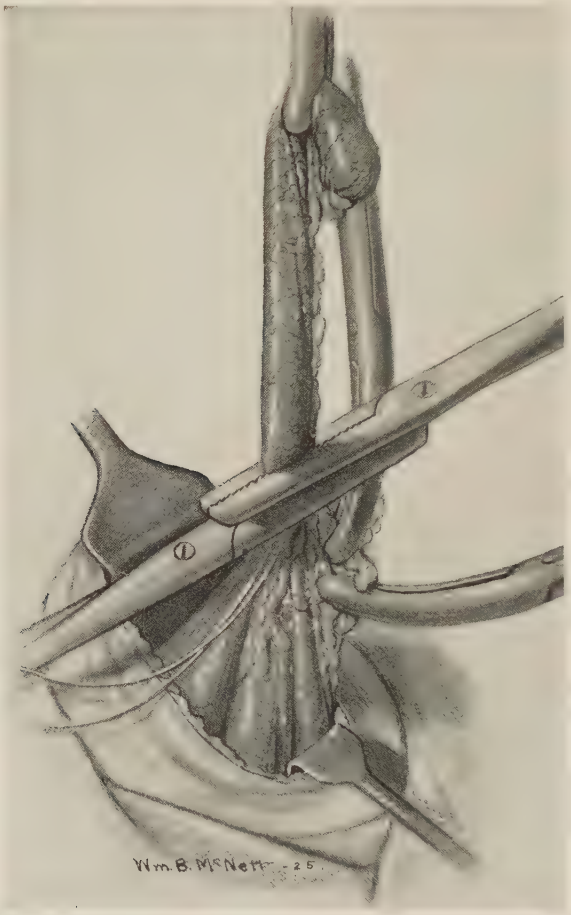


Fig. 887.—Appendectomy: The appendix is gradually delivered through the small incision by grasping and dividing adhesive bands and the meso-appendix. The base of the appendix is then doubly ligated with chromic catgut, and forceps applied, preliminary to division by the cautery. The ligature to the base of the appendix is used to tie the meso-appendix in sections over the stump. A purse-string suture also may be used.

ing the meso-appendix and bringing the appendix against the finger; (c) following down the anterior tænia of the cecum to the base of the appendix. In this procedure it is often convenient to first bring the cecum out through the incision and—as soon as the base of the appendix has been located and grasped by forceps—to immediately return the cecum and appendix to the abdomen, and then withdraw the appendix alone through the incision.

Removal of the Appendix, Preferred Method.—The appendix is removed from the tip to the base, by grasping in forceps and successively dividing the meso-appendix and any associated peritoneal

folds or adhesions, close to the appendix. The attachments are grasped with artery forceps, and divided; the appendix and base of the cecum are gradually liberated and brought through the incision. At the cecal attachment the appendix is doubly ligated with No. 1 chromic catgut, grasped 2 or 3 mm. distal to the ligature by two crushing forceps, and divided between the forceps by the actual cautery; the remaining crushing forceps is now removed and, with the ends of one of the ligatures which have been left long, the meso-appendix and divided adhesions are successively ligated from within outward over the stump of the appendix; the ligature ends are then cut short, the stump returned to the abdominal cavity without tension, observed for any possible bleeding, and the wound closed in separate layers—the peritoneum, the internal oblique and transversalis, the external oblique, and the skin and subcutaneous tissues being united separately; the deeper layers by continuous No. 0, or No. 1 chromic catgut, the skin and fat by buried and subcuticular No. 00 plain catgut, an intracuticular suture of fine silk, or by Michel's clips.

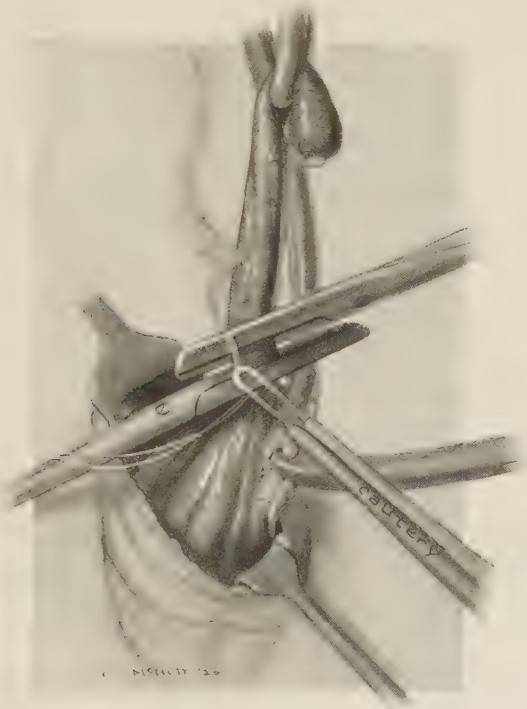


Fig. 888.—Appendectomy: Appendix has been divided, vessels being controlled with clamps, the base of the appendix is being divided between crushing forceps by a cautery.

In *acute appendicitis* the same incision is used, manipulation and exposure of the abdominal contents avoided as far as possible, and salt solution or local anesthetic solution is not permitted to enter the peritoneal cavity. No attempt is made to remove serum, seropus, or recent odorless pus. If a gangrenous or perforated appendix is removed, the peritoneum may be closed without drainage if only liquid pus is present. If there is solid greenish or grayish exudate, necrotic tissue, or old dead and odorous pus, drainage should be used, and it should also be used if fecal concretions, blood-clot, or other foreign bodies have been left in the abdominal cavity. As a rule, limited drainage only is required, a small rubber-tube being carried into the pelvis to the culdesac of Douglas, and a cigarette-drain to the stump of the appendix. If general peritonitis is present and it is evident that the removal of appendix will be difficult and require the introduction of the hand into the abdomen, or partial evisceration, the operation should immediately be terminated by introducing a soft-rubber tube to the pelvis and several cigarette-drains to isolate the appendix, which is not removed. If the incision is only 3 to 5 cm. long and of the gridiron type, no sutures are

required. The drains are removed between the fourth and sixth days, and the wound permitted to close spontaneously. Secondary hernia is rare after these small muscle-splitting incisions, but common after vertical incisions with drainage.

Objections to McBurney's incision are the lack of room, and difficulty in handling conditions in the upper abdomen or pelvis without a second incision. The McBurney incision may be enlarged to 7 or 8 cm., to permit the admission of a small adult hand for exploration. If more room is required, the anterior sheath of the rectus is divided by extending the incision of the external oblique mesially, and the rectus muscle and inferior epigastric artery retracted to the midline.

After a simple appendectomy without drainage or infection, the patient usually is permitted to be out of bed on the fourth or fifth day, and to go home on the seventh day.

A supporting bandage of adhesive-plaster dressing should be continued for about five weeks. Work not requiring muscular strain may be undertaken after the second week, and laborious work after the fifth week.

2. **Battle's incision** is a vertical lower midrectus incision; the anterior sheath of the rectus is divided in the line of the skin-incision, and the rectus muscle displaced mesially and not divided, the posterior sheath of the rectus and the peritoneum being divided on the line of the skin-incision. Battle's incision gives a strong wound-closure, but there is some danger of damaging the nerves which supply the rectus muscle, with a secondary wasting and weakness. It is not well adapted for drainage, being located too near the midline.

3. **Davis' incision** consists of a transverse incision over McBurney's point, dividing both the skin and external oblique muscles and the sheath of the rectus; the fibers of the internal oblique and transversalis are separated. It has the advantage of giving a larger opening than the McBurney incision, with somewhat greater tendency to hernia, particularly if drainage is employed.

Postoperative Complications.—A. **Hemorrhage** may occur into the colon or into the peritoneal cavity. Hemorrhage into the colon follows inversion of the stump of the appendix, the proximal or recurrent branch of the appendicular artery leaking from the inverted stump into the cecum. The patient shows progressive signs of hemorrhage without intra-abdominal symptoms. Usually after eight or twelve hours a quantity of blood and clots are expelled *per anum*.

Fig. 889.—The Richardson appendiceal retractor.

Diagnosis is made by the progressive pallor, weakness, increasing pulse-rate, air-hunger; increasing leukocytosis without abdominal irritation, distention, or evidence of free fluid in the abdominal cavity; and the finding of blood by rectal tube, withdrawn enema, or in the bowel-movement. The incidence is $\frac{1}{2}$ per cent. after simple inversion of the appendicular stump.

Prophylaxis.—(1) Ligation, crushing, and careful thermocauterization of the stump before inversion; (2) inclusion of the arterial branch in the meso-appendix by a loop in the purse-string suture; (3) avoidance of inversion of the stump in appendectomy.

Hemorrhage into the peritoneal cavity results from failure to tie all bleeding-points, slipping of a ligature, mass-ligature of the meso-appendix, especially where it is fatty and brittle; from hemophilia, leukemia, jaundice, or other blood-dyscrasia.

Symptoms.—1. Moderate hemorrhage: There is a slight pallor, increase in the pulse-rate from 80 to 110, tendency to faintness and syncope; bleeding spontaneously ceases, but there is great danger of secondary infection of the clot from the appendicular stump, with severe secondary peritonitis or abscess.

2. Massive hemorrhage is evidenced by shock, air-hunger, increasing leukocytosis, and localized or shifting dulness with more or less abdominal distention. The symptoms appear in from two to twelve hours after the operation.

Prognosis.—The patient may die from the hemorrhage, or from the secondary peritonitis; a large intra-abdominal blood-clot after a simple appendectomy predisposes to a very serious, and often fatal infection.

Treatment.—1. Intracecal hemorrhage should be treated by the Fowler position, avoidance of stimulants, and the application of ice-bags over the lower right quadrant of the abdomen, subcutaneous injection of 1/60 grain of atropin, and the intravenous injection of 10 c.c. of a 5 per cent. solution of calcium chlorid. The hemorrhage is often spontaneously arrested but, if there is evidence of continued or recurrent bleeding, the wound should be reopened without undue delay, and the vessel occluded by ligature.

2. Intra-abdominal hemorrhage after appendectomy is so dangerous from the secondary infection of the clot, that the abdomen should be reopened as soon as the diagnosis has been made, to thoroughly remove the clots, provided the patient's condition will withstand the additional traumatism. If peritonitis is already present, the excess of clot should be removed as quickly as possible and with the least possible manipulation, the bleeding-points ligated, and a large cofferdam or Mikulicz's drain introduced to wall-off the area of bleeding, and to prevent infection from residual blood-clot.

A simple and unnecessary appendectomy should not be done during an abdominal or pelvic operation which probably will be followed by some oozing of blood into the peritoneal cavity. To reduce intra-abdominal oozing, a very tight abdominal binder, a subcutaneous injection of horse-serum or thromboplastin, and a small, typed-blood transfusion are desirable. Tannic acid may be given by rectum.

B. **Pylephlebitis** is characterized by recurrent chills, fever, and sweats, with enlargement of the liver. The diagnosis should be confirmed by operative exploration of the liver, best under local or spinal anesthesia, with possible drainage of accessible abscesses. The condition is almost invariably fatal.

C. **Peritoneal Infection.**—Localization of the peritonitis, both before and after operation, is evidenced by: (1) Localization or limitation of the intra-abdominal mass; (2) reduction in the area of reflex rigidity of the overlying abdominal wall; (3) decrease in tympany, the general abdomen becoming flatter and softer; (4) passage of gas and fecal material by rectum; (5) cessation of vomiting; (6) stabilization of temperature and pulse-rate, and (7) relief from pain.

With evidence of localization well established for forty-eight hours, the *competence of localization* should be tested by: (1) The use of a 1-pint soap-suds enema. If this causes the expulsion of gas and fecal material and is not followed by increased pain or tympany, there may be given by mouth (2) one or two teaspoonfuls of hot water or hot thin barley-water every hour. The quantity and

variety of food are very gradually increased, if no unfavorable symptoms are produced. The return of abdominal pain, tormina, nausea, and increase in pulse-rate, temperature, or abdominal tenderness indicate that the localization is incompetent, that liquids or food by mouth should immediately be stopped, and a possible gastric lavage given. (See Treatment of Peritonitis, p. 982.)

Postoperative feeding in peritonitis *after localization* should progress as follows:

1. First Three Days: Quantity, 1 to 4 drams; at intervals of from one to two hours: Hot water, hot barley-water, plain albumin-water, toast-water, 5 per cent. dextrose-water, whey, plain weak hot tea.

2. Third to Sixth Day: Quantity, 2 to 4 ounces, every three hours: Cold water, Vichy or Apollinaris, champagne, beer, clear strained chicken- or mutton-broth, thin strained cereal gruels, ovaltine, Eskay's food, malted milk.

3. Sixth to Ninth Day: Quantity, 4 to 6 ounces, every three or four hours: Junket, wet toast, gelatin jelly, chicken jelly, cornstarch, custard, soft coddled or poached egg, orange albumin, plain ice-cream. As a rule, milk or milk-products should be avoided in the early treatment of peritoneal infection.

For tympany the rectal tube should be used after an enema of 1 pint of milk of asafetida, or a 10-grain asafetida suppository may be given every two hours. More effective is a milk-and-molasses enema (consisting of 3 ounces each of warm milk and the dark, heavy New Orleans molasses), or the more irritating "triple enema" (consisting of magnesium sulphate, 1 ounce; glycerin, 1 ounce; turpentine, $\frac{1}{2}$ ounce; and water to make 5 ounces). All enemas should be given slowly, at the temperature of the body, and through a short rectal tube by gravity, the container preferably not being raised over 10 or 15 inches above the level of the body. Large enemas under pressure may escape through the cecum into the abdominal cavity, even during the second week after operation. Evacuant enemas should not be used during the first twenty-four or forty-eight hours after operation. During this period usually they are ineffective and cause local irritation.

Opiates in appendicitis are used to relieve the pain while preparation is being made for operation, and for the postoperative pain during the first twenty-four hours after operation. During these periods $\frac{1}{6}$ grain of morphin may be given by hypodermic every three hours if there is urgent need, but the opiate should be avoided as far as possible. After twenty-four hours morphin should not be used, because the postoperative distress is then due to conditions that are obscured but not relieved by the opiate. If the pain is due to gastric distention or retention, lavage should be used; if from tympany, the rectal tube and appropriate enemas should be employed; if due to a distended bladder, catheterization; if there is excitation, delirium, restlessness, which often follows the preceding use of opiates or alcoholics, or if the evidence is of retention toxemia or dehydration, elimination should be favored by hypodermoclysis, intravenous infusion, and other measures. The use of morphin or other opiate alone for these postoperative complications shows that the attendant is lazy or incompetent. During postoperative treatment every effort should be made to maintain metabolism and elimination. Morphin reduces metabolism, slows oxidation of the tissues (favoring acidosis), reduces all forms of elimination except by the skin, and favors secondary restlessness and delirium. In the old and the toxic particularly, and in those with already seriously damaged parenchymatous organs, it should be avoided.

D. **Postoperative ileus** (*jejunal toxemia*) is characterized by regurgitant vomiting of jejunal contents, intense prostration, and alkalinosis. It *should be treated* by an early high enterostomy, a No. 14 to 18 French soft-rubber catheter being

introduced into the jejunum, and anchored by purse-string sutures to the intestines and by interrupted sutures to the abdominal wall. Continuous hypodermoclysis with decinormal saline solution, and the free use of intravenous saline injections (300 to 500 c.c. of 5 per cent. glucose or dextrose in physiologic saline being given very slowly into a vein once or twice daily) are of value. From 3000 to 6000 c.c. of saline solution may be given subcutaneously every twenty-four hours by continuous infusion.

E. **Postoperative Fecal Fistula.**—When a gangrenous or perforated appendix has been removed, the stump ligated, and drainage used, gas and small quantities of fecal material often begin to escape from the wound three to six days after the operation from sloughing of the stump or, more rarely, sloughing of adjacent portions of damaged intestinal wall. In modern practice these fistulæ close in from seven to fourteen days, and give no further trouble. Persistent fistulæ indicate technical errors in the operation, retention of foreign bodies, local tuberculosis, syphilis, or malignant disease.

Treatment.—Prophylaxis. Formerly persistent intestinal fistulæ after appendectomy were common, and were due to excessive manipulation and injury to the bowel, the insertion of many sutures into the cecum, or massive and prolonged drainage with secondary pressure-necrosis of the intestinal wall. All primary drains should be removed within seven to ten days. After ten days, gauze and rigid tubes may ulcerate into the bowel. Purse-string, occluding, or enfolding sutures in the cecum, after the removal of an infected appendix, are unnecessary and harmful, favoring large sloughs in the head of the cecum. If there is septic peritonitis a simple ligation of the stump of the appendix without the application of the cautery suffices. The ends of the ligature to the appendix may be brought out of the abdominal incision, to fix the appendiceal stump close to the incision. The farther the infected stump is from the opening in the abdominal wall, the greater the tendency to form a persistent sinus or fistula. Silk, linen, or other non-absorbable sutures or ligatures should not be left in the abdominal cavity, and fecal concretions and other foreign bodies that may have escaped from the appendix should carefully be removed at the time of operation. After the removal of the drains, the opening, as a rule, should not be repacked but may be gently swabbed with tincture of iodin. The wound and surrounding skin should be kept clean, the cavity may be filled with balsam of Peru, or with a 50 per cent. paste of red iodid of bismuth in white petrolatum. Chronic fistulæ should be tested, to see if they communicate with the intestine, by injecting methylene-blue solution and noting if this escapes by anus; by filling the sinus with bismuth paste and taking skiagrams; or by carefully exploring for retained foreign body, or associated tuberculous, syphilitic, or actinomycotic infection.

Chronic persistent fistula should be treated by operative excision and closure as elsewhere described.

Mucocele.—With the obstruction of the lumen, the appendix may be distended by mucus, forming a cyst from 1 to 7 cm. in diameter. Originating from the base of the appendix or from the appendiceal stump, the mucocele separates the layers of the walls of the cecum, and may strip up the mucosa and obstruct the ileocecal valve. Malignant change is unusual.

The mass should be enucleated, and this may necessitate partial resection of the head of the cecum. If there is peritonitis or acute obstruction a simple incision to permit drainage through the mucosa into the colon, or an external cecostomy should be used.

Carcinoma, the most common tumor of the appendix, comprises $\frac{1}{2}$ per cent. of all carcinomas of the intestinal tract. Two types are found:

1. *Benign adenocarcinoma*, forming an indurated mass in the tip or wall of the appendix, or a diffuse enlargement with or without stenosis of the lumen.

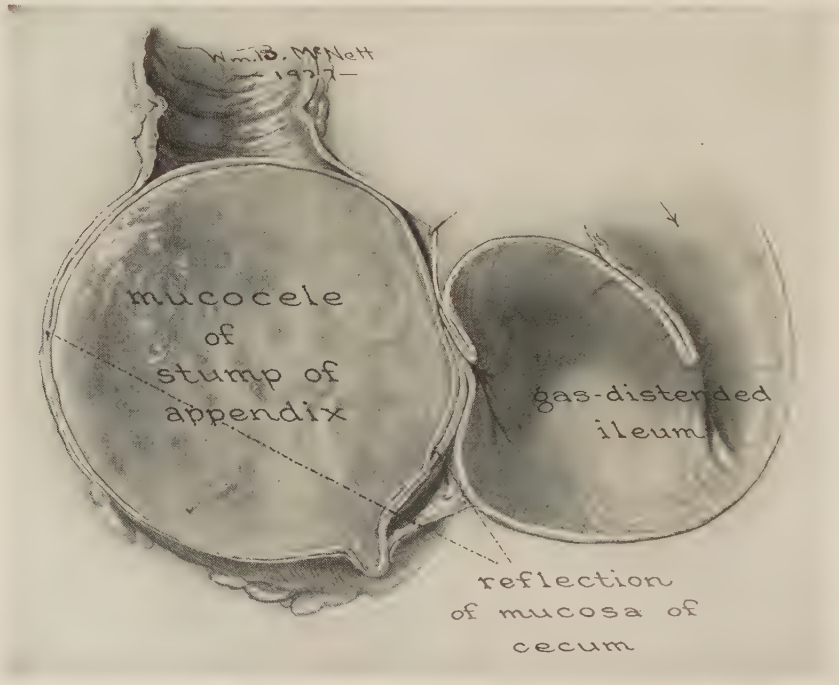


Fig. 890.—Obstruction of ileocecal valve and of cecum by mucocele developing from the stump of the appendix which in enlargement had partially stripped off the mucous lining of the cecum causing obstruction of the ileocecal valve. Patient was an obese man, seventy years old, who had had an appendiceal abscess drained eighteen years before, and for three years had had symptoms of partial intestinal obstruction which finally became complete. Preoperative diagnosis: Carcinoma of the cecum. Emergency operation followed by death from generalized peritonitis. (Dr. John V. Hartman.)

Ulceration is rare. The growth usually develops between the ages of sixteen and twenty, producing symptoms suggesting a chronic appendicitis. It does not recur or give metastasis. The cells are small, polygonal or spheroidal, in small alveoli. It is questionable if these benign tumors should be considered true carcinomas.

2. *Columnar-cell* or *gelatinous adenocarcinoma* is rare, and occurs in middle life; the growth, probably starting from the mucous glands, resembles a basal-cell carcinoma. It is characterized by local infiltration, recurrence after removal, and metastasis. Early operative extirpation is indicated.

CHAPTER LII

THE LIVER AND BILIARY SYSTEM

LIVER

Physiology.—The liver is the largest gland in the body, has the greatest power of regeneration, and a capacity five times the normal need. After removal of 70 per cent. of the dog's liver, regeneration occurs in fourteen weeks (Mann).

The known functions of the liver include:

1. *Conversion and storage of:*
   a. Sugar—glucose into glycogen.
   b. Fats—desaturated—lecithin possibly formed.
   c. Proteins—amino-acids into ammonia and urea.
   d. Pigment—waste hemoglobin converted in part into bilirubin (animal chlorophyl).
2. *Metabolism of:*
   a. Fibrinogen, antithrombin and calcium (blood-clotting bone-hardening).
   b. Cholesterol—insulator, cell builder—de-esterized (?).
   c. Bile-salts—eliminants, digestants.
3. *Destruction of:*
   a. Bacteria—chiefly from the digestive tract.
   b. Toxic proteids, from intestinal putrefaction, conjugated with sulphuric or glycuronic acid to harmless ethereal sulphates, etc.
   c. Alkaloids—strychnin, atropin, nicotin, etc.
4. *Sequestration of:*
   Mineral poisons, arsenic, mercury, phosphorus, etc.
5. *Elimination of:*
   Bile.

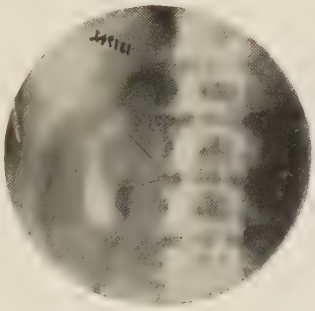


Fig. 891.—Roentgenogram showing large number of gall-stones in the gall-bladder (Carman).

The liver secretes bile at a pressure of 300 mm. of water. If the common duct is obstructed and the pressure rises above this point, the bile in the liver will be absorbed by the lymphatics and pass into the blood-stream, the patient becoming jaundiced.

Tests for Hepatic Disease:

1. *Cholecystography* (Graham-Cole) is based upon the fact that phenoltetraiodophthalein is eliminated in the bile by the liver, and collects and is concentrated in the normal gall-bladder, producing a shadow upon the roentgenogram. Stones in the gall-bladder produce defects in the shadow, and by this test over 90 per cent. of gall-stones may be demonstrated, especially if the drug is given by intravenous injection. Graham claims the test to be 97 per cent. effective when the drug is

given intravenously, 75 per cent. effective when given by mouth. A delayed or imperfect shadow in the gall-bladder indicates insufficient concentrating power and, therefore, disease of the gall-bladder, obstruction of ducts preventing bile from entering the gall-bladder, or an impaired eliminative power of the liver. The last probably is of little value, as the gall-bladder has been well visualized in acute yellow atrophy of the liver and in chloroform poisoning. During the test the patient should be starved, to prevent the rapid emptying of the gall-bladder.

2. *Icterux index*, which is normally 0.2 to 0.6, is determined by comparing the color of the blood-serum with standard solutions of potassium bichromate. Jaundice is visible when the icterus index is at 1.5 or more; between 0.6 and 1.5 it is evident that latent jaundice is present.

3. *Van den Bergh's test* is the diazo-reaction applied to blood-serum, and is a very delicate test for latent jaundice. The normal amount of bilirubin in the blood-serum is from 1 : 400,000 to 1 : 1,000,000. The unit employed is 1 : 200,000. The qualitative or direct test with prompt reaction is found in obstructive jaundice. In the early stage the reaction may be direct, delayed direct, indirect, or biphasic. Hemolytic jaundice is usually associated with an indirect or delayed direct reaction, while a biphasic or combined reaction suggests jaundice from hepatic disease—toxic or infectious jaundice. These finer differentiations, at first claimed, have not fully been confirmed. The test is valuable in showing slight latent forms of jaundice, and in indicating whether the jaundice is increasing or subsiding.

4. *Dye-elimination Test* (Rowntree-Rosenthal).—Five milligrams of phenoltetrachlorphthalein is injected intravenously for every kilo of body weight or, perhaps better, 2 mg. of bromsulphthalein (Rosenthal) per kilo of weight. As these drugs are eliminated like bilirubin by the liver, the test depends upon the rapidity with which the dye is removed from the blood. Retention of the dye is not always associated with bilirubin retention and, therefore, the test has a limited value. It is helpful, however, in the diagnosis of cirrhosis and carcinoma of the liver, although the injection produces a very troublesome thrombosis of the veins.

5. *Urobilin Test.*—Urobilin is formed by bacterial action on bilirubin in the intestines or biliary ducts. Urobilin is absorbed by the portal circulation, and reconverted to bilirubin by the liver. If from one-third to four-fifths of the liver is obstructed, bilirubin is not converted and eliminated by the liver, but escapes through the urine (bilirubinuria). Bilirubinuria, therefore, suggests that bile is entering the intestine, and that the liver is seriously damaged.

6. *Protein Metabolism.*—The amount of urea-nitrogen in the blood varies with the efficiency of the kidneys. In serious disease of the liver there is often a decrease of urea-nitrogen in the blood in relation to the total non-protein nitrogen, with increased amount of ammonia in the urine. This condition, however, may result from other causes.

7. *Hemoclastic crisis of Widal* is based on the impaired ability of the liver to detoxicate protein split-products that circulate with an anaphylactic reaction (*leukopenia*). After an all-night fast, 200 c.c. of milk are given, and the leukocytes counted every twenty minutes for one hour. The test is of little value as a digestive leukopenia is not infrequent.

8. *Carbohydrate Test.*—A positive rise in the blood-sugar, after the injection of 30 to 50 gm. of levulose taken after a twelve to fifteen hours' fast, may suggest a disturbance in carbohydrate metabolism in the liver; but as extrahepatic organs also convert and store glycogen, the test is unreliable.

In the diagnosis of biliary disease, the laboratory tests for the most part should not be depended upon. Tests for the retention of dye eliminated by the liver like bilirubin, the levulose-tolerance test, the conjugation-of-toxic-proteins test, all leave much to be desired. The van den Bergh diazo-test for bilirubin in the blood is of value in showing latent jaundice, whether the jaundice is increasing or decreasing either before or after operation and, in a limited way, differentiates extrahepatic obstruction from hemolytic jaundice. The clotting and calcium clotting-time is instructive, although it does not always show what the tendency to hemorrhage will be during or after an operation. The plasma carbon-dioxid combining-power (normally 56 to 65 volumes per cent.) gives a clue as to acidosis or alkalinosis. Acidosis, shown by an increased carbon-dioxid combining-power and an increase in blood-chlorids, if sufficiently marked, results in convulsions or tetany. It is to be combated by the free use of liquids, glucose, and alkali. It is noteworthy that in biliary obstruction acidosis is usual, while in high intestinal obstruction alkalinosis with decreased carbon-dioxid combining-power and a decrease of chlorid is to be expected. An ileus, however, may complicate biliary disease. Alkalinosis should be suspected if the patient has continuous, regurgitant

vomiting of the upper intestinal type, and is to be treated by the free use of fluids, glucose, sodium, and ammonium chlorid.

Final products of protein metabolism, urea and creatinin, show amounts in the blood that vary with production and the eliminative power of the kidney. Blood-urea, normally 26 mg. per 100 c.c. of blood, is in serious excess when 125 mg. or more are found; blood-creatinin is normally 2 mg. per 100 c.c. of blood, 10 mg. or more show a serious excess; and a marked increase of either product is serious. Blood-chlorids, normally 566 to 600 mg. per 100 c.c. of blood, are decreased in alkalinosis and increased in acidosis, with increased plasma carbon-dioxid combining-power. Deficiency in available calcium, as is usual in jaundice, not only favors operative and postoperative hemorrhage, but may lead to tetany.

Many of the laboratory tests necessitate starvation, which, especially in fat persons, may lead to acidosis. The drugs employed may have a toxic action upon the liver-cells.

For the very ill patient, therefore, tests requiring starvation or the employment of poisonous drugs should be avoided, and in all cases it is important to avoid these tests the week immediately preceding a serious operation upon the biliary system. Before, during, and after operation upon the biliary system, the maintenance of biliary efficiency is most important.

Treatment of Hepatic Deficiency.—1. *In All Cases:* Water, 4000 to 8000 c.c. daily, through mouth, rectum, subcutaneous tissues, and veins; glucose, 500 to 1000 c.c. of tested 5 or 10 per cent. solution intravenously daily, additional amounts by stomach and rectum, but never subcutaneously; elimination (laxatives, lavage, enema).

2. *Avoidance of:* Ether, chloroform, cyanosis (nitrous oxid), morphin, alkaloids, meat.

3. *Salt solution*, 4000 to 8000 c.c. daily, under the skin or in veins; or *ammonium chlorid*, 200 to 500 c.c., by rectum daily in *alkalinosis*. There may be vomiting, convulsions, tetany from an associated high intestinal obstruction.

4. *Alkalies* in acidosis, stupor, coma: Fisher's solution, 500 to 1000 c.c. intravenously, 200 to 1000 by rectum, daily.

5. *Calcium chlorid* in jaundice: Intravenously, 5 c.c. of 10 per cent. solution daily, for three days before and, at times, after operation.

6. *Cooked liver* (250 gm. daily) and *bile* in bile loss (fistula).

Anomalies of the Liver.—1. *Congenital* transposition of the liver occurs usually with situs inversus of the abdominal organs, the right lobe occupying the left abdomen. The liver may be tilted forward, so that the edge projects below the costal margin, simulating enlargement.

2. *Acquired (Riedel's Lobe)*: A tongue-like projection from the lower edge of the right lobe of the liver, usually associated with and attached to an enlarged gall-bladder, is found in chronic cholecystitis.

Movable liver may occur as a part of a general visceroptosis, from relaxation of the ligaments, the anterior abdominal wall, or the distention produced by recurrent ascites. *Lacing* or *Corset Liver:* A deep transverse groove follows atrophy from the pressure of the ribs in tight lacing, the wearing of a tight belt, or the like.

Traumatic Injury.—The liver is very frequently injured by blows, kicks, falls, crushing and run-over accidents, and may be severely lacerated by the end of a fractured rib.

Enlargement of the liver (with associated softening), passive congestion, and fatty degeneration predispose to rupture. Traumatic rupture involves the right lobe of the liver six times as often as the left, and the convex surface twice as frequently as the concave.

Varieties.—1. *Contusions of the liver* without laceration of the capsule of Glisson.

2. *Peripheral laceration* with rupture of the capsule.

3. *Central laceration* which may be followed by hematoma and cyst, or abscess formation. A part of the liver may be pulpefied or completely detached. Stab and incised wounds of the liver at times cause violent hemorrhage. Perforation, laceration, and pulpefication follow gunshot wounds. Portal blood escapes under a normal pressure of about 30 mm. of mercury, the hepatic arterial blood under the higher general blood-pressure. Bile is secreted under the low pressure of the hepatic venous blood. Detached hepatic cells, entering the hepatic veins, are carried to the lungs producing embolism.

Symptoms are shock, following an injury of the upper right abdomen, associated with the evidence of intra-abdominal hemorrhage. The treatment is to control hemorrhage, by opening the abdomen and packing or suturing the liver. In most cases, the patient is in such bad condition from shock and loss of blood that a packing with gauze is the only treatment to be thought of. Fortunately the blood-pressure in the liver is so low that firm packing usually is effective.

Abscess of the Liver.—*Varieties:* (1) Solitary, amebic, or tropical abscess; (2) multiple or pyemic abscesses; (3) suppurative pylephlebitis through the portal vein; primary focus in the appendix, rectum, or elsewhere; (4) suppurative cholangitis through bile-passages, from gall-stones, round-worms; (5) hydatid; (6) part of a general septicemia or pyemia, through the general circulation.

Tropical abscess, amebic abscess, and **solitary abscess** follow amebic dysentery, and are due to infection by the *Entamœba histolytica.*

Pathology.—A single abscess may contain 500 c.c. or more of chocolate-colored pus resembling anchovy sauce, and is usually found in the upper and posterior portions of the right lobe of the liver. The abscess gradually enlarges, and finally ruptures through the diaphragm into the pleura, lung, pericardial sac; or into the stomach, intestines, peritoneal cavity, pelvis of the right kidney, venæ cavæ, or anterior abdominal wall, either between or below the costal cartilages. The Amœba coli is present in the pus and also in the stools.

Etiology.—Tropical abscess of the liver occurs in the tropics, and in those who have been infected in the tropics; in Europeans rather than natives, in men between the ages of twenty and forty, in proportion of thirty men to one woman. It is favored by alcoholism and malaria.

Symptoms.—The condition may be latent, without fever or suggestive symptom except enlargement of the liver, up to the time of rupture. A prominence or bulging of the upper right abdomen, dull aching pain, with evidence of pleurisy, crepitation of the right lung, pain in the right scapula, cough from irritation of the phrenic nerve or from irritation of the pleura or lungs may cause the patient to seek medical advice.

Pyogenic abscess of the liver follows injury, pentrating wounds; direct ulceration into the liver, from gall-stones, gastric or duodenal ulcer, migration

of foreign bodies (such as pins, needles, and fishbones), the entrance into the hepatic duct of round-worms which die and start infection, the suppuration of hydatid cysts, and the invasion by the Distoma hepaticum or Coccidium oviforme. The latter usually produce multiple abscesses. The liver may also be invaded by pus through direct contiguity from purulent peritonitis, perinephritis, empyema, and the like. Multiple abscesses of the liver often result from pylephlebitis, in which septic invasion of the portal veins occurs from appendicitis, ulcers of the stomach, duodenum, bowel, pancreas, or spleen. Pylephlebitis also occurs from pelvic infection, as after hysterectomy, hemorrhoidectomy, pelvic peritonitis, infections or inflammation of the umbilical stump, and typhoid fever. The portal vein may contain pus or suppurating thrombi instead of blood. The abscesses in the liver are small, and the condition progresses to a fatal issue in from four to six weeks.

Symptoms.—Recurrent chill, fever, and sweat; a marked intermittent or remittent temperature, followed by gradual enlargement of the liver and, later, local tenderness over the liver. In the absence of pulmonary infection, a severe chill during the early stages of appendicitis is ominous.

Pyemic abscesses of the liver occur in pyemia, in septic inflammation of the bones of the cranium and the ear, in ulcerative and malignant endocarditis, and in septic disease of the lung; the infection being carried through the hepatic artery.

Prognosis.—The mortality is 75 per cent. from solitary abscesses of the liver, and nearly 100 per cent. from multiple abscesses of the liver.

Exploratory operation is desirable in suspected multiple abscess to prove the diagnosis and attempt drainage. In solitary amebic abscess the patient should first be treated by full doses of emetin subcutaneously, and by mouth and bowel. Under this treatment the parasites may die, the abscess becoming sterile and inspissating. Recovery may then follow spontaneously or after a simple aspiration. To drain the abscess, the liver is exposed by incision, walled off by gauze pads and, if the abscess cannot be located by palpation, exploration may be made through the wound by an exploring needle. Blind aspiration of the liver through the abdominal or thoracic wall is unwise, as leakage and dissemination of the infection may follow. If pus is found, the abscess may be drained in two stages. In the first stage, the affected portion of the liver is exposed, and walled off by sutures and gauze packing. Two or three days later, when the adhesions have formed, the liver is opened by a cautery or knife. If the abscess is not accessible through the abdomen, transthoracic drainage may be used, one or two of the lower ribs being resected, and the diaphragm divided and sutured to the chest wall, isolating the pleural cavity from the wound. If amebæ are found in the pus, the use of emetin is continued, and the cavity irrigated with a solution of emetin and quinin. If the abscess ruptures into the peritoneum, pleura, or pericardium, immediate operation should be done, with separate drainage of the invaded cavities. The possibility of an occasional second amebic abscess should not be forgotten. With pyemic abscesses the liver is enlarged, the surface smooth, showing yellow foci of pus under the capsule. With pylephlebitis the pus is in the branches of the portal vein; with suppurative cholangitis the foci are in the smaller bile-ducts, and gall-bladder and

the larger ducts may be distended by pus. Small abscesses often fuse, forming larger collections.

Pylephlebitis.—A purulent phlebitis of the portal vein follows pyogenic infections in areas drained by the portal system. About $\frac{1}{2}$ of 1 per cent. of patients with acute appendicitis develop pylephlebitis.

Etiology.—(1) Gangrenous appendicitis with septic thrombophlebitis in mesenteriolum. Occasionally the appendix is only slightly infected. (2) Diverticulitis and infections along the intestinal tract. (3) Infections in the pelvis, especially about the rectum and in the culdesac of Douglas, including abscesses following vaginal hysterectomy.

Pathology.—The process begins as a septic thrombosis in the portal radicals from which bacterial emboli are carried to the liver, resulting in multiple metastatic abscesses. Pus and purulent thrombi may be found in the portal vein. Infection also may be carried by the lymphatics of the portal fissures and retrocecal and retrocolonic spaces with extension in the subhepatic and subphrenic space. The portal vein externally may be normal, or the adjoining tissues infiltrated, edematous, or matted. At times the walls of the vein show purulent infiltration.

Symptoms usually develop within the first three days of an acute attack of appendicitis, but rarely may be delayed even to six weeks. Onset: (1) Severe chill, sweat, temperature of 104° to 105° F. (2) Recurrent chills daily or every second or third day, with sweat and high temperature, later (3) increasing size of the liver with tenderness, often with a soft and relaxed abdomen. (4) Increase of blood bilirubin and at times jaundice. Blood-cultures are negative as a rule. The Bacillus coli, which is usually responsible, is seldom found in the general circulation.

Prognosis.—Pylephlebitis causes 5 per cent. of all deaths following acute appendicitis. Death occurs from sepsis or cholemia. The mortality is over 90 per cent.

Treatment.—(a) *Prophylactic*, early operation, adequate drainage of purulent accumulations about the appendix and intestinal tract. (b) Opening and drainage of thrombosed veins above the caput coli found during operation for appendicitis.

Wilm's (1907) ligated the veins of the ileocecal angle, avoiding the artery. Necrosis of the cecum may follow.

Braun's Operation of Ligation of the Ileocolic Vein.—The ascending colon is drawn to the right, the small intestine to the left, The vein is seen or felt as a thrombosed cord running from the ileocecal angle obliquely upward to the right of the spine toward the angle of the transverse mesocolon and the mesentery of the small intestine. The thrombosis and infection often spreads beyond the ileocecal vein and incision and drainage is to be preferred to ligation.

Ligation of the portal vein, suggested by Neuhof and used in 2 cases by Culp, apparently offers no hope of relief. Localized liver abscesses that are accessible should be drained.

Echinococcus (*hydatid*) **cysts** start from infection by the larval form of the Tænia echinococcus, which is a short tapeworm of four or five segments, inhabiting the intestines of the dog, the eggs being discharged into the feces. In the stomach of man, the egg-shell is digested and the six-hooked embryo (oncosphere) penetrates the stomach and reaches the liver or other organs. The

cyst consists of an external wall or *ectocyst* with a laminated chitinous layer, and an inner layer or *endocyst*, both being surrounded by a layer of reactive fibrous tissue formed by the invaded organ. Great numbers of parasites may develop from the endocyst and, at times, form into secondary and tertiary cysts. Usually the daughter-cysts are endogenous, or develop within the primary cysts; but they may also be exogenous and penetrate the cyst wall with the development of small cysts external to the main cyst. The cysts are thin walled, whitish or translucent, and contain a clear, "spring-water," non-albuminous fluid (having a specific gravity of 1.005 to 1.010), containing chlorids, and frequently scolices and characteristic barbed hooklets. The cyst may rupture, or shrink or suppurate after the death of the parasites.

Etiology.—The condition is more frequent in men, and in those who are closely associated with infected dogs. The disease is prevalent in Australia and in Iceland, and is not infrequent in Germany, Italy, and adjacent European countries. It is rare in the native born in North America. Several years may elapse between the infection and the discovery of the cyst.

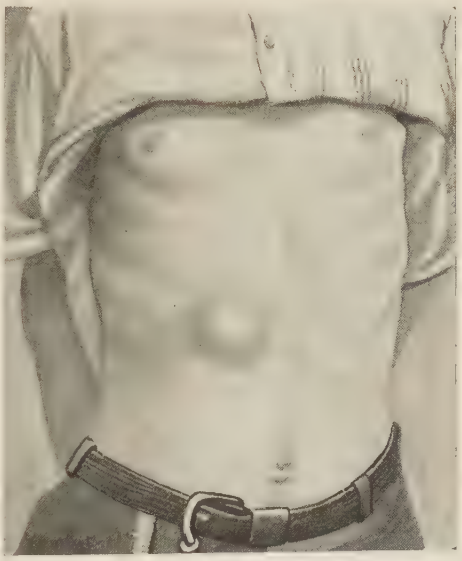


Fig. 892.—Hydatid cyst of the liver causing a painless protrusion of the upper right abdominal wall. After excision secondary cysts formed in the region of the abdominal scar.

Symptoms.—As a rule, a slowly growing rounded mass develops, and projects below the right costal margin with little discomfort or effect upon the general health. Rupture of the cyst may be spontaneous or the result of an injury, the patient feeling that something has given way, and the mass disappearing with signs of peritonitis and a general toxemia, expressed by urticaria, fever, nausea, and other general disturbances. The cyst may rupture through the diaphragm into the pleura or lung, or into the stomach, intestines, pericardium, venæ cavæ, or other adjacent organs. Suppuration is shown by a temperature, sweat, chill, local tenderness, and signs of a localized or spreading peritonitis.

Diagnosis.—The mass is elastic and, on pressure, a quivering jelly-like sensation or *hydrated thrill* is sometimes felt. The blood shows eosinophilia. An evening temperature is at times present, and may continue for weeks even after the removal of the cyst. The "spring-water" contents of the cyst and the contained hooklets are diagnostic.

Mortality.—The mortality from operation for uncomplicated hydrated cysts is 5 per cent. or less, but recurrence is frequent in the wound, liver, or other part of the abdomen.

Treatment.—While theoretically desirable, excision and resection (without

rupture) of the portion of the liver containing the cyst is often dangerous and difficult. Evacuation and drainage by a two-stage operation is, therefore, usually preferred. Owing to the infectious nature of the contents, aspiration should never be done except with a cyst that has been previously exposed, walled off by gauze-covered cotton pads, and injected through a fine needle with a parasiticide (1 or 2 per cent. solution of iodin, or a 1 per cent. solution of formaldehyd), then evacuated and united to the opening in the abdominal wall, and packed with iodoform gauze. The operation may be done in two stages to avoid infection of the general peritoneal cavity. In the first stage the area of involved liver is isolated in the wound by stitches or gauze, the sac being injected, opened, and drained several days later. The sac undergoes suppuration under drainage, and separates from the liver, when it may be withdrawn. The patient should be kept under observation for months or years, being watched for the development of secondary cysts in the abdominal wall, omentum, peritoneum, pelvis, or other organs. The patient who has apparently made a good recovery from hydatid cyst of the liver, may after one or more years show a number of recurrent abdominal cysts. The development of these cysts may be restrained by the intravenous use of salvarsan or neosalvarsan.

Actinomycosis of the liver is rare as a primary condition, the infection usually spreading from a primary intestinal, peritoneal, or thoracic focus. Firm nodular masses form on the liver, and break down, forming abscesses containing the characteristic "sulphur" granules. The condition is rarely amenable to treatment, and is usually hopeless.

Cirrhosis of the liver (*portal cirrhosis, Laennec's cirrhosis, alcoholic cirrhosis, hobnail liver*) is characterized by an increase in interlobular fibrous tissue, degeneration of the liver-cells, and obstruction to the portal circulation; occurring usually between forty and fifty years of age, chiefly in males. The liver becomes small and firm, with a hob-nailed surface. Portal obstruction leads to engorgement of the veins in the collateral circulation of the liver.

Collateral Circulation of the Liver.—1. Accessory portal system of Sappey: (a) The veins of the round and falciform ligaments, connecting with the epigastric and internal mammary veins (forming at the umbilicus the *caput medusæ*); (b) veins through suspensory ligaments to diaphragmatic veins, vena azygos, and superior vena cava.

2. Esophageal with the gastric veins, forming large varices at lower end of esophagus and in cardia. Veins of colon and duodenum with left renal.

3. Retroperitoneal veins, connecting portal and inferior caval branches and also the veins of Retzius, forming a subperitoneal anastomosis.

4. Inferior mesenteric and hemorrhoidal opening into the hypogastric veins. Rarely a patent ductus venosus.

The varices in the esophagus and rectum (internal hemorrhoids) may bleed very freely. Marked ascites is usual, and secondary tuberculosis occurs in from 15 to 25 per cent. of patients. A similar type of cirrhosis of the liver is seen in connection with certain enlargements of the spleen, notably splenic anemia or Banti's disease.

Surgical Treatment.—Disability is largely due to the ascites. Repeated tapping (*paracentesis abdominis*) depletes the body of fluids and albuminoids,

and causes wasting and inanition. To improve the collateral circulation the operation of Talma and Morrison is used. Talma's operation consists of a vertical 15-cm. incision through the upper right rectus muscle, the rectus being displaced outward from its posterior sheath, and the great omentum sutured into the cavity thus formed. A collateral circulation is thus established between the omental veins and the superior epigastric vessels. To increase the effect of the operation, Morrison scarifies or lightly abrades the outer upper surface of the liver, and adjacent surfaces of the diaphragm and anterior abdominal wall, so that adhesions will form. These operations may be performed under local anesthesia, ethylene or nitrous oxid. If the patient is in poor condition, it is wise to return a considerable portion of the evacuated fluid into his veins. *Mortality* is about 15 per cent.

Saphenous Peritoneal Anastomosis.—A vertical incision is made from 5 cm. above the middle of Poupart's ligament, downward for 15 cm., over the femoral opening and internal saphenous vein. The vein is divided at the lower end of the incision, the distal end ligated, and the proximal end turned up and anastomosed by fine arterial silk to the edges of a hole made in the peritoneum. The valves guarding the upper end of the saphenous vein prevent reflux of the blood into the peritoneum, and permit ascitic fluid to enter the vein continuously. The entrance of moderate amounts of ascitic fluid into the blood-stream is apparently harmless. An undue quantity may cause hypertension, and may rupture pulmonary and hepatic capillaries. If the opening becomes obstructed upon the one side, the operation should be repeated upon the other. Properly performed, this operation has a low mortality and, if the opening does not become occluded, the patient is completely relieved of the ascites.

Splenectomy.—Removal of the spleen reduces the amount of portal blood entering the liver by one-fifth or more, relieves the liver of a certain degree of toxemia, and increases the collateral circulation through adhesions formed in the splenic area. Splenectomy is to be considered as an operation for ascites, especially when enlargement or disease of the spleen is present. In advanced alcoholic cirrhosis, the operation has a high mortality and is less effective.

Hypertrophic biliary cirrhosis (*Hanot's cirrhosis*) is characterized by an interlobular fibrosis of the liver, with obstruction of the biliary ducts, jaundice, and enlargement of the liver and spleen. It is a chronic condition continuing from four to ten years, the patient dying of intercurrent disease, cholemia or icterus gravis.

Surgical Treatment.—(a) Splenectomy: This reduces the destruction of red blood-cells, the formation of bile-pigment, and the toxemia of the liver. Certain cases are relieved by this operation. (b) Cholecystoduodenostomy or cholecystogastrostomy: While there is no obstruction of the larger bile-ducts in biliary cirrhosis, the drainage of the gall-bladder by a large artificial opening made directly into the stomach or duodenum has occasionally been followed by disappearance of the jaundice, and improvement in the patient's condition. This may be due to better drainage, with the relief of back pressure previously caused by the sphincter of Oddi.

Chronic perihepatitis (*sugar-ice liver, Zuckergussleber*) is characterized by a greatly thickened whitish capsule, contracted liver with little cirrhosis, more

or less chronic perisplenitis, a chronic proliferative peritonitis, and chronic interstitial nephritis with recurrent ascites but without jaundice. Operative treatment offers little promise of relief.

Tumors of the Liver.—Of the benign tumors, angiomata or nevi are the most common. Usually they are only a few centimeters in diameter, develop in middle or advanced life, and produce no clinical symptoms. They rarely require treatment.

Congenital angiomas form large masses that may reach to the umbilicus, and are not encapsulated as in the acquired form.

Cysts (other than the hydatid cysts) occur particularly in connection with bilateral polycystic disease of the kidney and, as a rule, require no treatment. If marked they may be aspirated or resected.

Carcinoma of the liver is usually multiple and secondary, producing firm umbilicated nodules, associated with jaundice, emaciation, cachexia, and ascites. The primary growth is found chiefly in the stomach, pancreas, uterus, sigmoid, or cecum. Primary carcinoma of the liver is rare. Sarcoma is also rare as a primary growth of the liver. Melanotic sarcomas and sarcomas of bone frequently metastasize to the liver as well as to the lung. The melanotic sarcoma of the retina of adults almost invariably kills by metastasis to the liver. Localized primary malignant growths of the liver may be extirpated, hemorrhage being prevented by surrounding the affected area by a series of interlocking or chain ligatures; the large section of the liver, containing the growth, then being removed. With the exception of the small carcinomatous growths springing from the gall-bladder, early recurrence has been the rule.

JAUNDICE

Jaundice (*icterus*) is characterized by the staining of the tissues from an excess of bilirubin circulating in the blood.

Bilirubin, formed from waste hemoglobin by Kupffer's cells of the reticulo-endothelial system of liver, spleen, bone-marrow, and other organs, is stored in the liver and eliminated with bile.

Jaundice is characterized by: (1) Pigmentation; (2) deficient available calcium, fibrinogen, glucose, water; (3) cholemia.

Tests: (1) Van den Bergh; (2) icterus index.

Glucose deficiency results in:

1. Deficient combustion—loss of heat and energy.

2. Imperfect combustion of fats with the formation of aceto-acetic acid and acetone, causing acetonemia, acidosis, coma, vomiting, drowsiness, stupor, acetone odor of breath, fall in alkaline reserve, and a rise in ammonia in urine.

3. Imperfect conversion of amino-acids into ammonia and urea, with uremia, convulsions, eclampsia.

4. Imperfect detoxication conjugation of split proteins, with the formation of the toxic substances, tryptophan, indol, indoxyl, producing vasomotor depression and shock. Indoxyl sulphuric acid and ethereal sulphates are not properly conjugated by sulphuric or glycuronic acid.

5. A complicating high ileus results in chlorid deficiency, alkalinosis, vomiting, tetany.

Varieties: (1) Biliary or obstructive jaundice; (2) hepatic, toxic, or infectious jaundice; (3) hemolytic jaundice.

1. *Obstructive jaundice* occurs from an obstruction: (a) Of the *biliary capillaries*, as in biliary cirrhosis, or (b) of the *hepatic* or *common bile-duct*. The ducts dilate and thicken proximal to the point of obstruction. With chronic or recurrent obstruction of the common duct there is a progressive thickening and contraction of the walls of the gall-bladder, which often is filled with biliary sand or stones. (c) From obstruction at the *ampulla of Vater*, however, which usually results from cancer of the gall-bladder the common duct may dilate to a diameter of 3 or 4 cm., and the gall-bladder become greatly dilated and palpable. In any form of obstructive jaundice the back pressure in the fine biliary capillaries leads to rupture and to the entrance of bile into the lymphatics and blood-vessels. The obstruction may be due to gall-stones, roundworms, or other parasites which have entered the biliary duct, or pressure upon the ducts from without, as in biliary cirrhosis, pancreatitis, cancer, movable kidney, and the like.

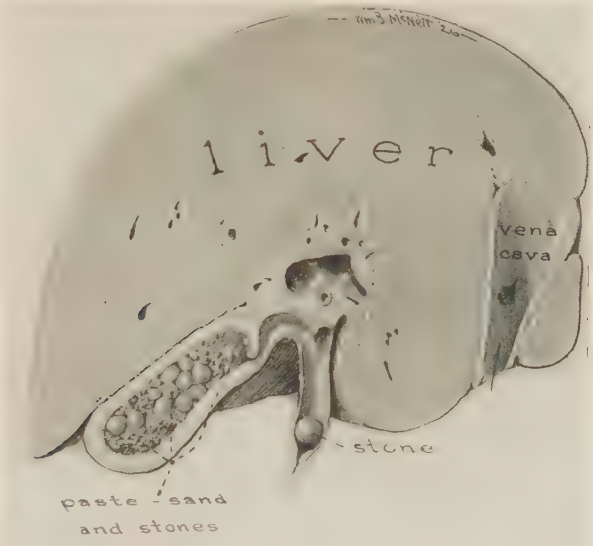


Fig. 893.—Small, contracted, thickened gall-bladder filled with gall-stones, bile-sand, and bile-mud, characteristic of recurrent calculus obstruction of the common bile-duct.

2. *Hepatic jaundice* results from degeneration of the polygonal cells of the liver, which are unable to transfer the bilirubin from the blood to the bile.

3. *Hemolytic jaundice* follows excessive destruction of red blood-corpuscles and has been observed in animals after the liver has been removed, proving that bile pigments are formed outside of the liver. In this form of jaundice, if the hemolytic action of the spleen is responsible, recovery follows splenectomy.

In jaundice, the bilirubin of the blood fixes the calcium. As calcium is not available, there is a tendency to hemorrhage, softening of the bones, and possibly tetany. The function of the liver is also seriously impaired. Jaundiced dogs no longer detoxicate benzoic acid, a product of proteid decomposition. With non-obstructive jaundice, urobilin (formed by bacterial decomposition of biliverdin in the intestines or biliary ducts, and carried to the liver by the portal

blood) is no longer removed by the liver, but is eliminated by the kidneys. This occurs when one-third of the liver is removed experimentally (Mann).

Symptoms.—The jaundice leads to discoloration of all tissues except those of the central nervous system. In obstructive jaundice, bile does not enter the intestine, so the stools are clay colored. The urine is orange, green, or brown. The tears, saliva, milk, and sputum are usually unstained. In obstructive jaundice if the gall-bladder has been removed the icterus occurs much earlier due to the lack of concentration and absorption of bile from the gall-bladder.

Clinical Symptoms of Obstructive Jaundice.—1. *Skin:* Golden yellow to brownish color, itching, with petechiæ, xanthomata, occasionally furuncles.

2. *Circulatory:* (a) Bradycardia; (b) irregularity; (c) lowered blood-pressure.

3. *Nervous System:* (a) Irritability; (b) depression; (c) coma; (d) delirium; (e) paralysis.

4. *Blood:* Tendency to hemorrhage, lengthened coagulation time, increased fragility of red blood-cells, cholemia.

5. *Digestive:* Anorexia, nausea, indigestion, meteorism, absence of bile from the stools with excess of fat (mixed fat and fatty acids).

6. *Bone Changes:* Osteoporosis.

7. *Urinary Changes:* Bilirubinuria, urobilinuria.

The slowing of the heart is possibly due to the fixation of calcium by bile-pigment. Itching of skin results from deposited bile-salts. Xanthomata, from deposits of cholesterol, occur under protracted hypercholesterolemia. Nervous symptoms may be due to circulating bile-salts or decreased available calcium. Blood changes occur from injury to capillary endothelium by bile-salts and the binding of plasma calcium by bile-pigment. Bone changes result from the decrease in available calcium. Urinary color, from elimination of bile-pigment in the urine. Stool changes, from incomplete fat absorption and bacterial change.

The jaundiced patient is not a good subject for operation, is subject to operative and postoperative hemorrhages, and has a tendency to postoperative cholemia and death.

Before operation upon a jaundiced patient, the calcium loss should be restored by three daily injections of 5 c.c. of a 10 per cent. solution of calcium chlorid (Walter), the clotting-time should be determined, and the dehydration and glucose deficiency corrected. Usually the patient will be benefited by one or more transfusions of 6 or 8 ounces of blood.

Treatment of jaundice is described under its various causes.

GALL-STONES

Gall-stones.—Concretions in the biliary system occur in the form of bile-mud, sand, gravel, and gall-stones. Usually the deposit takes place in the gall-bladder, but it also occurs in the ducts, including the hepatic radicles. The nucleus of the calculus may consist of epithelial cells, mucus, parasites, or other foreign bodies.

Varieties and Composition of Gall-stones:

1. *Pure cholesterin stones*, found in the gall-bladder when obstruction prevents the bile from entering, are whitish or yellowish, smooth, translucent, brittle,

waxy; crack or crumble on drying, and consist largely of crystallized cholesterin, soluble in ether or chloroform.

2. *Laminated cholesterin stones* are the common gall-stones and show on section yellowish layers of cholesterin, and brownish layers of bilirubin calcium. Cholesterin stones are round and oval if single, with a roughened surface; pyramidal or polyhedral if multiple, with surfaces polished by mutual attrition.

3. *Bilirubin-calcium stones* are small, brown or black, soft, brittle or hard, and of rounded, oval, or irregular shape, with a rough granular or mulberry surface. The color is dependent upon the amount of pigment present.

4. *Calcium-carbonate stones* are exceedingly rare. In very old gall-stones enough calcium carbonate may be deposited to produce a shadow on the roentgenogram. Cholesterin has about the same resistance to the rays as the adjacent soft tissues.

Point of Obstruction.—The neck of the gall-bladder, or the first portion of the cystic duct, is most frequently obstructed. The gall-bladder distends from the

Fig. 894.—Gall-stone, 6.3 x 4 cm., that had ulcerated into a large umbilical hernial sac with abscess formation, then through the gastric wall, and finally caused fatal duodenal obstruction.

mucus which forms within it and which cannot escape. The walls become thin, stretched, translucent (*hydrops of gall-bladder*), or whitish and thickened. From the distending pressure, the circulation of the mucous lining may be arrested with necrosis. In extreme cases the necrotic or gangrenous process spreads to the peritoneal coat of the gall-bladder. In chronic forms the gall-bladder contains clear mucus, or a turbid whitish or grayish fluid (so-called *white bile*). In acute obstruction the fluid is thick, turbid, with a grayish purulent deposit.

From ulceration or necrosis the gall-bladder may perforate into: (1) The adjacent stomach, duodenum, or colon (internal biliary fistula); (2) the general peritoneal cavity (diffuse peritonitis); (3) a walled-off area of peritoneum (local peritonitis, peritoneal abscess); or (4) the sac of an umbilical or ventral hernia.

Gall-stones entering the peritoneal cavity may become: (1) Encapsulated by fibrous adhesions; (2) produce a local cyst or abscess; (3) ulcerate into an adjacent viscus.

A gall-stone having a greater diameter than 3 cm. may, after ulcerating into the stomach or bowel, cause pyloric or intestinal obstruction. Ulceration into the liver occurs, at times with abscess formation.

Etiology.—*Age:* Seventy-five per cent. of gall-stones develop after the age of forty; gall-stones are found in 20 per cent. of all women, and 4 per cent. of all men. Under twenty the incidence is about equal in the two sexes.

Heredity is an indirect factor, by grouping bodily types with a metabolism favoring the developing of gall-stones.

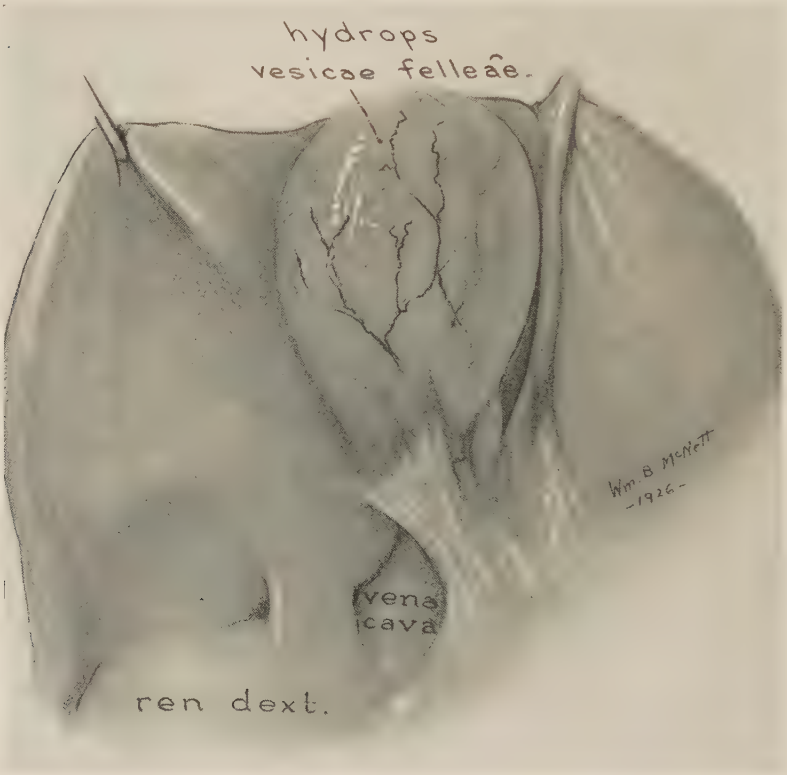


Fig. 895.—Hydrops of gall-bladder from obstruction of cystic duct, the walls are thin, distended by mucus. Hydrops should not be treated by cholecystostomy, as a permanent mucous fistula will result.

Pregnancy.—Initial symptoms often develop during pregnancy, when stagnation and change in composition of the bile occurs with a tendency to biliary infection.

Cholecystic infection is the most important cause of gall-stones. Bacteria, especially the acid-forming colon group, the Bacillus coli, B. typhosus, and the streptococcus, act upon the bile and precipitate the alkaline-soluble cholesterin and other substances, which are bound together by a colloid and thereby rendered relatively insoluble even in an alkaline solution. The B. coli is found in the walls of the gall-bladder in 46 per cent. of the cases (Moynihan).

Stagnation of bile may result from reduced movement of the abdominal walls and diaphragm, as in pregnancy, obesity, other forms of abdominal enlargement and distention, tight lacing, sedentary mode of life.

Hypercholesteremia.—Normally there is 140 to 160 mg. of cholesterol to 100 c.c. of blood-serum; a proportion above 192 mg. (hypercholesteremia) is thought to favor gall-stone formation.

Symptoms result from obstruction, pressure, irritation, ulceration, and perforation, and are described under cholecystitis, duct obstruction, jaundice, and pancreatitis.

Diagnosis.—1. In *gall-bladder:* By attacks of biliary colic or acute cholecystitis without jaundice; by roentgenography (unreliable except with cholecystography).

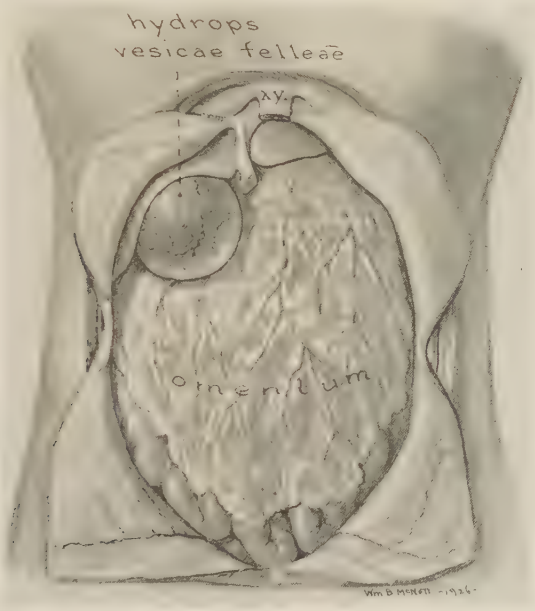


Fig. 896.—Hydrops of gall-bladder, more advanced, showing thin, translucent, distended wall of the gall-bladder with arborescent blood-vessels.

2. In *common duct:* By acute colic with jaundice (Charcot's intermittent fever); by operative exploration.

Treatment. 1. *Prophylactic* and *palliative:* (a) Prevention of obesity; (b) abdominal exercises, deep breathing, increased oxidation; (c) dietetic restriction of carbohydrates, fats, and meat, free use of green leaf vegetables; (d) elimination of food infection; (e) stimulation of flow of bile; alkalies, bile salts, salicylates, succinates, alkaline waters (Carlsbad), laxatives, duodenal drainage.

2. *For attack of colic:* Alkaline lavage, hot fomentations, hypodermic injections of morphin.

3. *Curative:* No solvent drug is known. Cholecystolithotomy, cholecystectomy, choledocholithotomy, or cholecystoduodenostomy is indicated—according to location of the stone and the associated lesions.

GALL-BLADDER

Physiology.—The gall-bladder is not essential to health, and is absent in certain animals (the horse, rhinoceros, deer, peccary, pigeon, and rat). In these animals the sphincter of Oddi develops as in animals with a gall-bladder. After removal of the human gall-bladder the cystic duct usually dilates. The gall-bladder has a capacity of about 30 c.c. or a little less than one hour's secretion of bile, the daily secretion being about 800 c.c. In the gall-bladder bile is concentrated to one-tenth of its previous volume, salt, cholesterol, pigment, and water being returned through the lymphatics to the blood, and mucus added. The gall-bladder is an elastic tension-bulb, filled through pressure from the biliary ducts. Its walls contain elastic tissue, but relatively little muscle, and active contractions of the gall-bladder are slow and imperfect. It empties passively through its own elasticity, and by the pressure of adjacent organs. Copher has shown that it is never completely empty. Meltzer's theory of contrary innervation as applied to the gall-bladder is in question. The flow of bile and the pancreatic juice from the ampulla is controlled more by the contractions of the duodenum than the sphincter of Oddi. The common duct runs obliquely 1, 2, or more cm. through the duodenal wall. During duodenal contraction it is obstructed, while peristaltic waves of the duodenum cause a milking effect with ejection of spurts of bile (Copher and Kodama). The flow of bile is stimulated more by oleic acids, a fat meal (egg-yolks and cream), and pituitrin than by magnesium sulphate in the duodenum. Under an anesthetic the pressure of bile in the gall-bladder is from 100 to 200 mm. of water, and in the common duct from 75 to 100 mm. At 600 mm. the obstruction by the duodenal wall is forced. It is difficult to empty the gall-bladder by pressure unless traction is made, straightening the curve of the cystic duct. Evidently the respiratory movements of the liver greatly aid the emptying of the gall-bladder.

The valves of Heister are apparently not of great importance, but check the passage of bile into or out of the gall-bladder, and aid in maintaining the gall-bladder as the uniform sampling organ of bile (Mann).

Congenital Anomalies.—The gall-bladder varies greatly in size, but seldom is congenitally absent. Accessory hepatic ducts may enter the gall-bladder or cystic duct.

Traumatic Injury.—Rupture of the gall-bladder, especially a dilated or hydropic organ, may follow blows or falls. The injury is followed by evidence of a progressive peritonitis, and should be treated by immediate cholecystostomy or cholecystectomy, as the free leakage of bile into the peritoneum may cause a fatal peritonitis.

Cholecystitis.—Inflammations of the gall-bladder may be tabulated as follows: (1) Acute catarrhal cholecystitis; (2) chronic catarrhal cholecystitis, including "strawberry" gall-bladder and papillary cholecystitis; (3) acute and chronic suppurative cholecystitis, empyema of the gall-bladder; (4) necrotic or gangrenous cholecystitis; (5) cholecystitis obliterans; (6) parasitic cholecystitis, and (7) malignant cholecystitis.

Cholecystitis is a chronic progressive disease, beginning with infection of the gall-bladder in early life, characterized by biliary colic in middle life, and by serious secondary complications in advanced years.

Pathology.—The gall-bladder may become infected: (1) Through the blood-stream (focal infection); (2) through the bile; (3) by an ascending infection from the duodenum; (4) by a contiguity of inflammation, and (5) by infection from the liver through the communicating lymphatics.

Chronic catarrhal cholecystitis may be characterized by enlargement and erosion of the lining papillæ. Minute denuded, whitish yellow, cholesterin-coated papillæ are often seen upon the deep red back ground of the inflamed

Fig. 897.—Acute and chronic catarrhal cholecystitis: Early "strawberry" type.

Fig. 898.—Chronic catarrhal cholecystitis: Advanced "strawberry" change.

mucosa ("strawberry gall-bladder"). Bacteria may be found in the mucosa or submucosa, when absent from the bile.

In chronic cholecystitis the gall-bladder wall changes from the normal translucent bluish to an opaque milky white color. In very chronic forms of cholecystitis a significant fibrosis of the portion of liver adjacent to the gall-bladder may be present. On palpation the wall is found to be thickened. With a finger in the foramen of Winslow and the thumb applied anterior to the common duct, enlarged periportal lymph-nodes may be palpated. The bile in the gall-bladder becomes darker in color, thick, tenacious, or even tarry. If the outlet to the gall-bladder is obstructed, the gall-bladder may contain clear mucus or grayish, brownish, or mucopurulent fluid, and no bile. If the inflammatory process is very acute, the lining mucosa may be dark green or black, and necrotic, and areas of gangrene may be found extending through the walls of the gall-bladder to adjacent purulent exudate upon the peritoneum.

Etiology.—Infection of the gall-bladder is exceedingly common, ranking second in the chronic intra-abdominal infections (the appendix being first). In 50 per cent. of the cases of cholecystitis the appendix also is diseased, which suggests the frequent passage of infection from the appendix to the gall-bladder. In middle-aged persons, notably in multiparæ, it is the most common cause of severe abdominal colic.

Infections of the gall-bladder develop as a rule during the first and second decade, but, as the local symptoms are unobtrusive, the condition is often overlooked. After fifteen to thirty years gall-stones usually have developed, so that the cholecystitis is commonly manifested by gall-bladder colic between the ages of thirty-five and fifty-five. After fifty-five, serious secondary complications—such as empyema, necrosis, or gangrene of the gall-bladder, perforation and peritonitis, acute hemorrhagic pancreatitis, hepatitis, intestinal obstruction from gall-stones, and other complications—are prone to occur. It is the rule that the gall-bladder, once infected, is always infected.

Hematogenous Infection.—Bacteria circulating in the general blood-stream, during typhoid, pneumonia, influenza, and septicemia, frequently invade the gall-bladder. Rosenow's experiments suggest that streptococci, entering the blood, attack the gall-bladder or other organs by a peculiar elective affinity. The cholecystitis of young children probably occurs in this way.

Bile-infection.—Bacteria in the alimentary tract, or in other structures drained by the portal circulation, are frequently picked up and carried (as shown by Adami) to the liver, where they are destroyed, disintegrated, and eliminated by the bile; or they may carry infection through the bile to the gall-bladder and ducts. The chief organisms that have been discovered in the gall-bladder are the colon bacillus, typhoid bacillus, and the streptococcus. Living typhoid bacilli have been found in the bile forty-five years after enteric fever, the patient being a typhoid carrier.

Ascending Biliary Infection.—The bacteria enter the ampulla of Vater, passing through the common and cystic ducts into the gall-bladder. This process may be aided by the reverse currents described by Bond, who found that carmin introduced into the rectum would ascend and pass out through a gall-bladder fistula.

Propinquity Infection.—The gall-bladder is involved by the spread of infection from an adjacent organ, as where an abscess perforates or benign or malignant ulcer of the stomach or other organ invades the gall-bladder.

Lymphatic Infection. Bacteria are conveyed by the communicating lymphatics. Graham has emphasized the importance of this last method. The sequence being: (1) Infection in the portal area, as from appendicitis; (2) secondary portal infection of the liver, with hepatitis; and (3) the spread of the infection from the liver through the lymphatics to the gall-bladder.

Amebiasis of the gall-bladder is rare, as the bile is an unfavorable medium for the development of amebæ. Rarely the Amœba histolytica may cause catarrhal or suppurative cholecystitis.

Giardia Infection.—Giardia are occasionally found and may at least be partially destroyed by intravenous injections of neo-arsphenamin.

Symptoms.—Gall-bladder disease is divided into three stages:

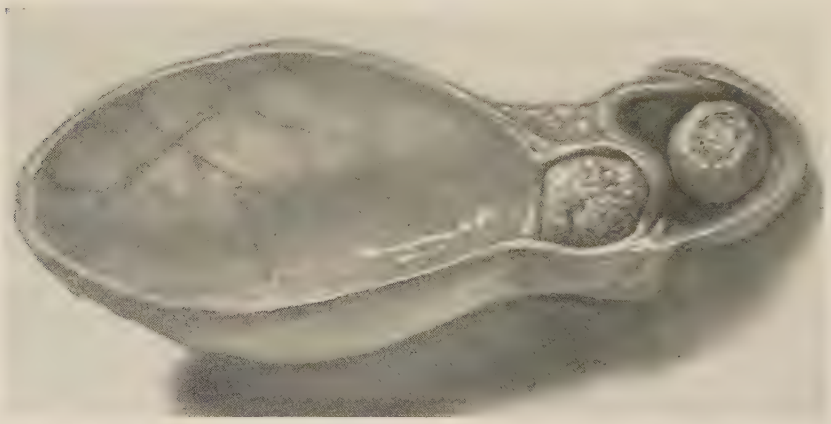


Fig. 899.—Gall-stones obstructing neck of gall-bladder and cystic duct with hydrops of the gall-bladder.

1. *Stage of cholecystic infection, toxemia,* and *catarrh,* which develops between the ages of ten and twenty, with digestive symptoms, characterized by fulness and distress after eating, sour, bitter eructations, belching and, more rarely, vomiting. The dyspepsia is of the qualitative type rather than the quantitative dyspepsia of ulcer, *i. e.*, the patient shows idiosyncrasy to certain articles of diet, such as shell-fish, boiled dinners, fried foods, pastries, fish, and the like, but may not be influenced by the amount of food eaten. Idiosyncrasy toward certain foods and the inability to handle certain staple articles (such as milk or eggs) are suggestive of biliary disease. It is one of the common conditions that cause the patient to report periodically to a physician for relief from so-called biliousness or indigestion, and is relieved temporarily by fasting, dieting, and alkalies, duodenal drainage, or by a calomel and saline course. Secondary focal and toxic symptoms occur, and include arthritic and muscular complications treated under the name of rheumatism, myalgia, lumbago, chronic arthritis, neuralgia, bilious sick headache, and various ocular symptoms. The operative mortality in this stage is low (0.5 to 2 per cent.).

2. *Stage of colic*, occurring usually between the ages of thirty-five and fifty-five, has as its characteristic symptom gall-bladder colic, the stones leading to recurrent obstruction of the outlet of the gall-bladder. The attack is of sudden onset, usually occurs at night, often after a heavy meal or dietetic indiscretion, and frequently develops during or after pregnancy. It is characterized by a sense of great pressure and distress, referred to the epigastrium and frequently radiating through to the back in the region of the eleventh rib. The patient feels that vomiting would give relief, and tries to induce vomiting by putting the finger down the throat, by taking soda, hot water, or a laxative. Vomiting may be followed by immediate relief, but usually the pain is so severe that the patient sends for a physician and a hypodermic is administered. The attack lasts from

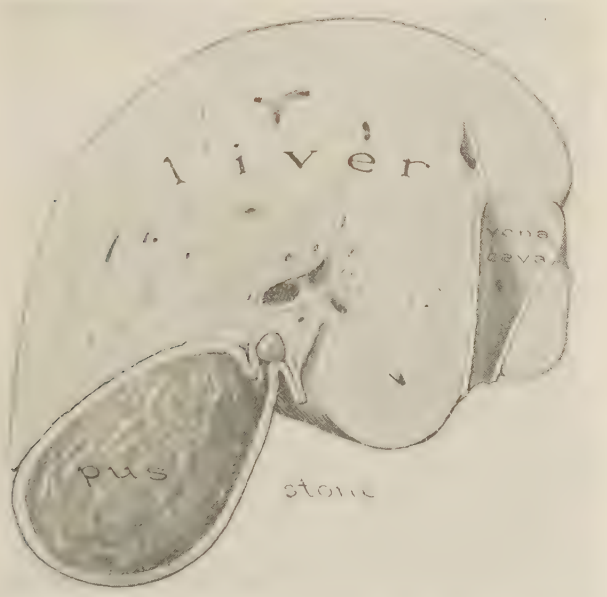


Fig. 900.—Purulent cholecystitis from stone obstructing cystic duct.

one-half to three hours, and the next day the patient can resume work. Gastric hypo-acidity or anacidity predominates.

Clinical Picture.—Nocturnal attacks of acute indigestion in a middle-aged obese person (most frequently a woman) with a sense of some internal pressure, which is relieved by induced vomiting, or requires a hypodermic injection of morphin, and which is entirely relieved the following day is almost surely a gall-bladder colic. Cholecystic colic, or a gall-bladder attack with distention and inflammation of the gall-bladder, without the presence of stones or the formation of pus, resembles a prolonged and mild attack of stone colic. The upper abdominal distress lasts several days, but an opiate is not required, as the pain is not as intense as that from stone; the patient avoids food, and may try to obtain relief by vomiting. The distended gall-bladder is often felt below the costal border. The onset and subsidence are less abrupt than with a stone, and a slight or moderate rise in temperature may be present.

It is to be emphasized that, in most subacute forms of cholecystitis and in gall-stones, tenderness over the gall-bladder on palpation or percussion is more often

Fig. 901.—Elevation of the upper lumbar spine for operations upon the biliary passages and liver.

absent than present. The patient usually complains of pain in the epigastrium or under the ensiform, and here tenderness is more marked than elsewhere over the abdomen. The operative mortality is moderate (2 or 3 per cent.).

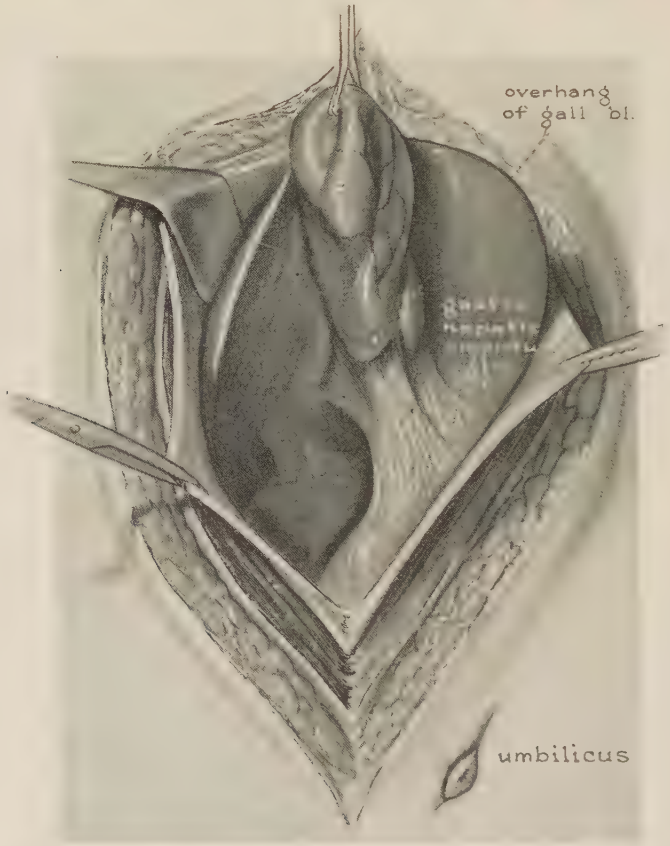


Fig. 902.—Cholecystectomy: Elevation of overhanging neck of gall-bladder to expose cystic duct and avoid injury to common bile-duct.

3. *Stage of Serious Complications.*—Purulent, gangrenous, ulcerative or perforative cholecystitis, and pancreatitis, occurring after forty-five are usually preceded by attacks of gall-stone colic. In a suppurative or gangrenous cholecystitis, the patient notes that the present attack is more severe and more prolonged than

any that preceded it. A severe gall-stone colic that lasts over thirty-six hours is usually associated with pus formation or necrosis of the gall-bladder. The patient is nauseated and vomits, has a moderate temperature (99° to 103° F.), the color is sallow and grayish, and the resistance of the enlarged gall-bladder, projecting below the costal margin, is often felt. If greatly enlarged and inflamed, the tip may come in contact with the peritoneum under McBurney's point, and a diagnosis of acute appendicitis be made. This mistake should not be made, if the examiner looks for the less evident part of the mass extending upward under the ribs. The operative mortality is high (5 to 30 per cent.).

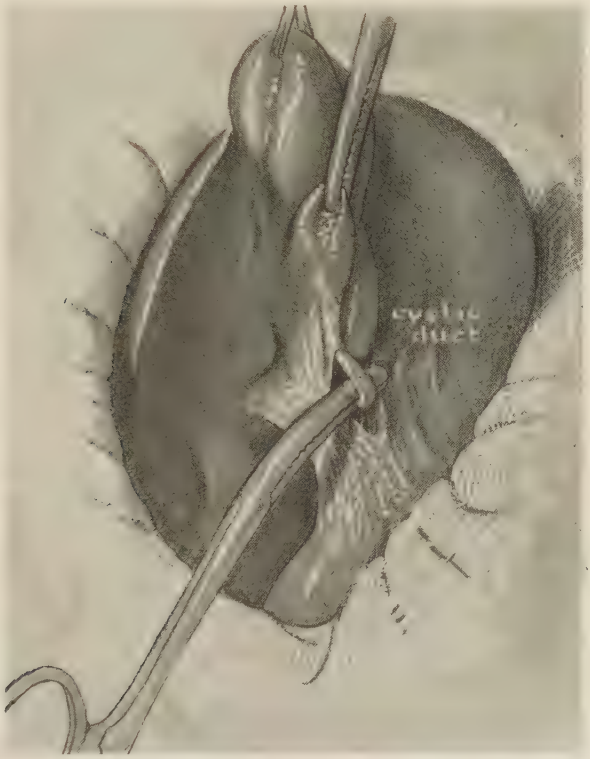


Fig. 903.—Cholecystectomy: The relationship of the parts when the neck of the gall-bladder is raised. The importance of clearly exposing the cystic duct before applying a clamp is evident.

Diagnosis.—The symptoms of an acute appendicitis are mimicked by those of acute respiratory infections and pneumonia; the symptoms of gastric ulcer, by those of pulmonary tuberculosis; the symptoms of cholecystitis or gall-stones, by disease of the heart and great vessels. Myocardial disease, coronary occlusion, aortitis, and angina may give symptoms referred to the upper right quadrant of the abdomen, the liver may be enlarged and tender and attacks may cause great distress, and occur at night. There is not the sense of pressure, however, impelling the patient to seek relief by induced vomiting, nor is the pain violent enough to require the use of an opiate. There is evidence of circulatory involvement, with cyanosis, pallor, edema, and slowing, rapidity, or irregularity of the heart action. Enlargement of the heart

may be present as well as the evidences of disease shown by the electrocardiogram. It is to be remembered that coronary obstruction and myocardial degeneration cause leukocytosis and fever. With *renal colic* the pain is in the loin, may extend along the course of the ureter to the bladder and genitals, and changes in the urine are found, while the Roentgen ray shows the shadow of a calculus in the ureter or kidney.

From a perforated *gastric* or *duodenal ulcer* the pain is even more severe than that of gall-stone colic and is often accompanied by shock, so that the patient

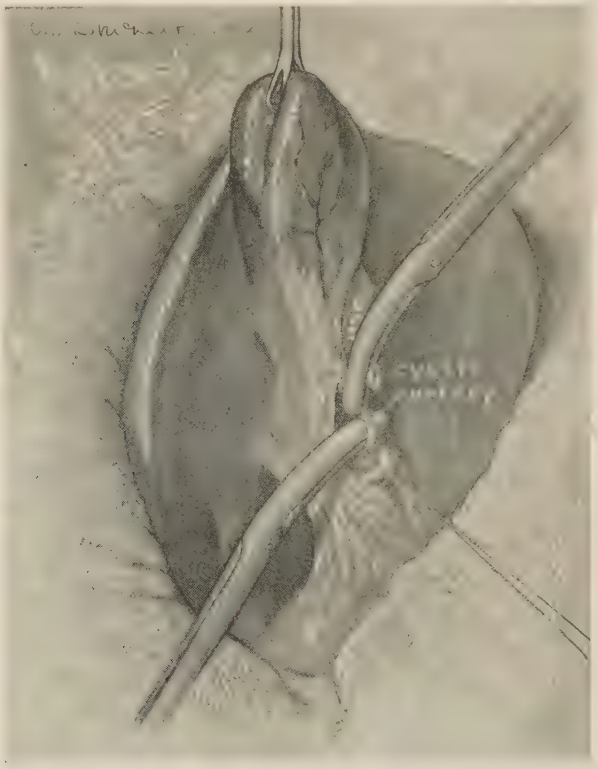


Fig. 904.—Cholecystectomy: The cystic duct is best exposed by sharp dissection with the scalpel. It should not be clamped until it has been clearly isolated close to the gall-bladder. The cysticus has been doubly ligated below with 0 chromic catgut, grasped by forceps above, and divided between the forceps and ligatures. The cystic artery is now exposed close to the gall-bladder, usually above and to the left of the duct. A tortuous artery in this region should be approached with caution, since it is probably the hepatic artery, which, of course, should not be divided. By careful exposure with sharp dissection carried close to the gall-bladder wall anomalous bile-ducts and the hepatic artery are best avoided.

may suddenly fall to the ground. The patient is usually younger, a man, and he does not attempt to obtain relief by vomiting. The greatest resistance and tenderness is often about McBurney's point, as the erosive chyme gravitates into the right iliac fossa. Rapidly developing evidence of free fluid and possibly gas in the abdominal cavity is suggestive and, at operation, a mucilaginous or possibly bile- or blood-stained fluid is found in the peritoneal cavity. In subacute or chronic perforation of a gastric or duodenal ulcer, the pain is less

severe but more continuous. It is only temporarily relieved by an opiate, and the sense of great epigastric pressure, which the patient tries to relieve by vomiting, is absent. The previous history indicates ulcer rather than cholecystitis and gall-stones.

In *movable kidney* with Dietl's crises, the attack occurs on movement and not at night. The kidney is low and very movable, and the pain is referred to the loin. Urinary changes may also be found.

Acute Appendicitis.—More frequently gall-bladder colic is mistaken for appendicitis than the reverse, the large inflamed gall-bladder forming a tender mass at McBurney's point. A high-lying inflamed appendix, however, may be

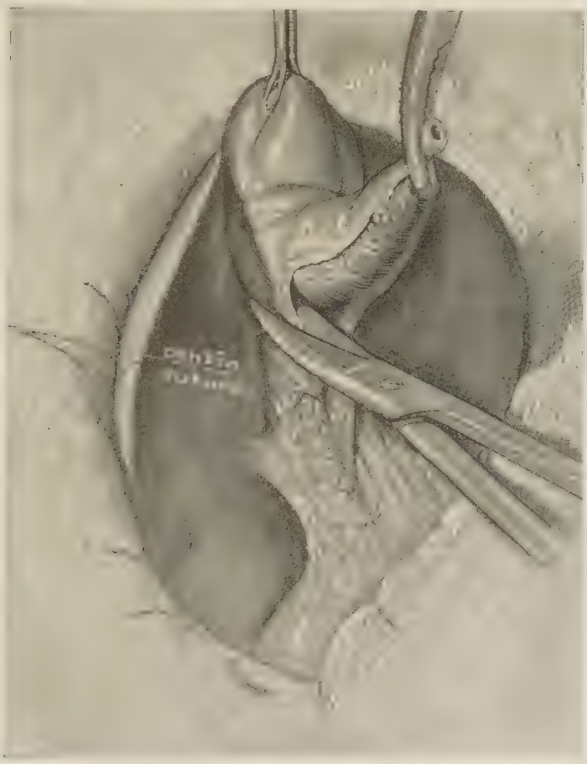


Fig. 905.—Cholecystectomy: Separation of the gall-bladder from its bed and the liver with follow-up closure of the peritoneal edges by a continuous fine catgut suture. Care should be taken that the needle does not perforate an hepatic duct.

mistaken for gall-bladder disease. With appendicitis, the first symptom is acute, diffuse, abdominal colic. With a cholecystic attack, the first pain is a sense of pressure referred to the upper abdomen and the epigastrium.

Acute pancreatitis resembles a gall-stone attack, except that it is very much more intense, producing shock or even collapse. One-sixth or one-fourth grain of morphin subcutaneously usually relieves the patient with gall-stone colic, while $\frac{2}{3}$ grain may be required to relieve the patient with acute pancreatitis. Free fluid in the abdomen rapidly develops, and there is increased resistance and tenderness in the epigastrium from the inflamed pancreas. An incision

reveals the characteristic spots of fat necrosis in the abdominal fat, and the "beef-broth" peritoneal fluid.

In *malignant disease* of the gall-bladder, pancreas, or stomach, the pain is less severe, the onset more gradual, and the symptoms progressive, usually with enlargement of the gall-bladder. If the cancer involves the gall-bladder, suppurative cholecystitis often results. The gastric crises of tabes, pains from acute pyelitis, diaphragmatic pleurisy, and herpes zoster should be differentiated by a careful study of the patient.

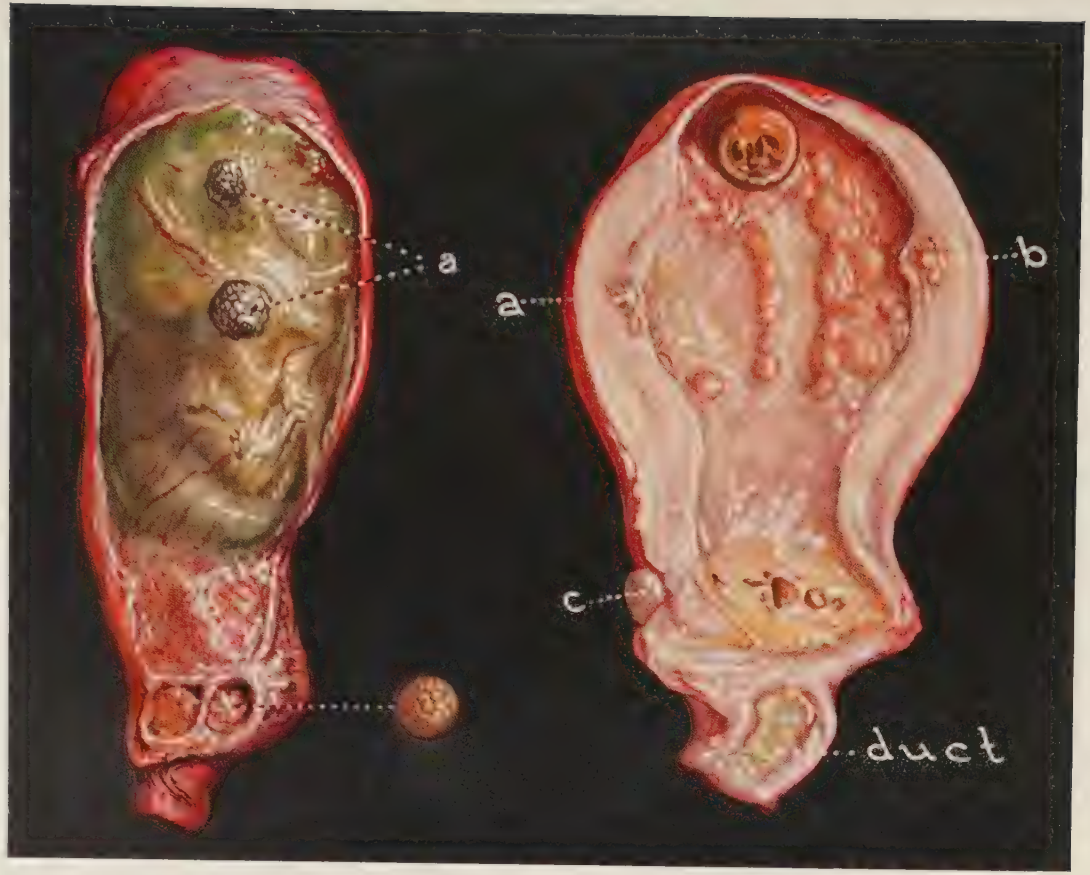
Papillary Cholecystitis.—In *chronic cholecystitis* papillomatous growths (usually of small size) occur upon the mucous membrane in 4 per cent.

Diagnosis of cholecystitis at operation is made by changes in the wall, the contents, the lining, and the lymphatics of the gall-bladder, and by adjacent adhesions, exudate, or changes in the liver.

Fig. 906.—Cholecystectomy: Covering of bed of gall-bladder by suture of visceral peritoneum of liver. This suture should be very superficial to avoid injury to an hepatic duct.

Prognosis.—Cholecystitis is usually a progressive permanent infection, producing mild digestive symptoms and reflex or toxic symptoms in early adult life; recurrent attacks of biliary colic in middle life, and serious and often fatal complications in late life. It is associated with progressive changes in the liver and pancreas in many cases. Early eradication of the disease is important.

Treatment.—Mild cases of cholecystitis may be relieved by diet, with restriction in sugars, starches, fats, and meats, the elimination of acid, fried, sour, salty foods and pastries, increased exercise to increase the portal circulation and the movements of the diaphragm, together with the internal administration of alkalies, laxatives, salicylates, and a course of appropriate vaccines. Five meals are ordered daily to favor the continuous secretion of bile. Foods rich in cholesterin, as eggs, fat, butter, cream, brains, sweetbreads, liver, kidneys, goose, duck, game, stews, gravy, fat fish (salmon, mackerel, blue fish, carp), peas, roe, fat beef, spiced foods, fried foods, and lentils are interdicted. Pies, mayonnaise, alcohol, coffee, and cocoa are also prohibited. All forms of animal fat should be taken in moderation, olive oil may be given before meals, especially if hyperchlorhydria is present. Deficient liver function is frequently due to constipation and intoxication through the portal circulation. Roast or boiled meat free from fat, cereals, green or leaf vegetables, fruit, skimmed milk, bread in moderation, alkaline mineral



A B

A, Advanced mucopurulent cholecystitis from stone obstructing cystic duct: *a*, Mulberry-shaped calculi in viscid contents of gall-bladder. B, Chronic purulent cholecystitis with carcinoma of the gall-bladder: *a*, *b*, Carcinomatous nodule; *c*, enlarged lymph-node.

waters, clear weak tea are permitted. A glass of hot water may be taken before meals, and 2 quarts by rectum on alternate days. Strong purgatives should be avoided. Sodium phosphate or Carlsbad sprudel salt may be taken in hot water night and morning, or glycerin 6 to 15 c.c. daily, or 20 c.c. during an attack.

Olive oil, sodium salicylate, bile salts, as sodium taurocholate, stimulate the secretion of bile. Mercurials, podophyllin, and medicinal soap also increase the secretion of bile. Sodium succinate or salicylate (0.3 gm. after meals) may

Fig. 907.—Large gall-stone scoop.

reduce the number of attacks of colic by thinning the bile. Duodenal irrigation and biliary drainage often give temporary relief.

Operation.—In the *first stage*, cholecystectomy is indicated, the patient usually is young, has good resistance for the anesthetic and operation, and the operative difficulties are not great. The mortality for cholecystectomy in this stage should not exceed 1 per cent., and depends almost entirely upon the skill and care of the surgeon.

In the *second stage*, with stones limited to the gall-bladder and without disease of the duct, cholecystectomy is also indicated. If there is serious associated disease or obstruction of the common duct, if the liver or pancreas is diseased—cholecystostomy, cholecystogastrostomy, or cholecystoduodenostomy should be substituted for cholecystectomy.

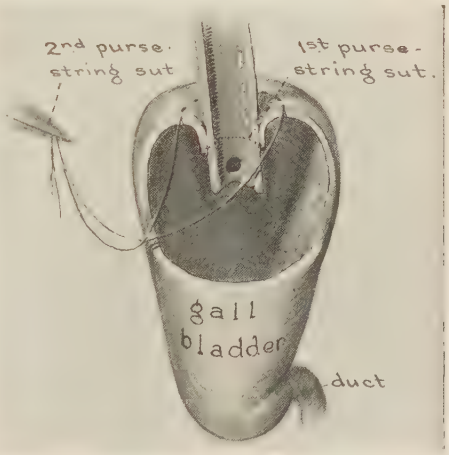


Fig. 908.—Cholecystostomy: Introduction of drainage-tube in gall-bladder, with inversion of the edges of the gall-bladder by two purse-string sutures.

The *third stage of cholecystitis*, that of severe complications, is usually treated by cholecystostomy or the anastomosis of the gall-bladder to the stomach or duodenum. The patient is usually past middle life, the myocardium is often degenerated, and there are serious changes of the liver and other parenchymatous organs. In this stage, local anesthesia with procain, with or without an associated analgesia by ethylene or nitrous oxid-oxygen, should be substituted for the use of ether or chloroform. If there is obstructive jaundice, the patient should be prepared for operation by the daily injection intravenously, for three days preceding the operation, of 5 c.c. of a 10 per cent. solution of calcium chlorid. This reduces the clotting-time and improves the patient's resistance for the operation. In obstructive jaundice, a slow decompression of the liver is desirable. Cholecystectomy for purulent or necrotic cholecystitis has a moderate mortality before the

age of thirty-five, but is a very dangerous operation after middle life for the patient who is very obese, or who has marked degenerative changes in the liver and other organs. If the patient's condition will permit, the condition of the liver, the gall-duct, the pancreas, and the appendix should be determined during the operation. When the patient is not in a serious condition, the appendix should be removed.

Mortality from operation during the second stage of cholecystitis is about 3 per cent.; for operations during the third stage, 10 per cent. or more. The morbidity of the operation depends largely upon how the surgeon operates. The mortality depends chiefly upon when the operation is done.

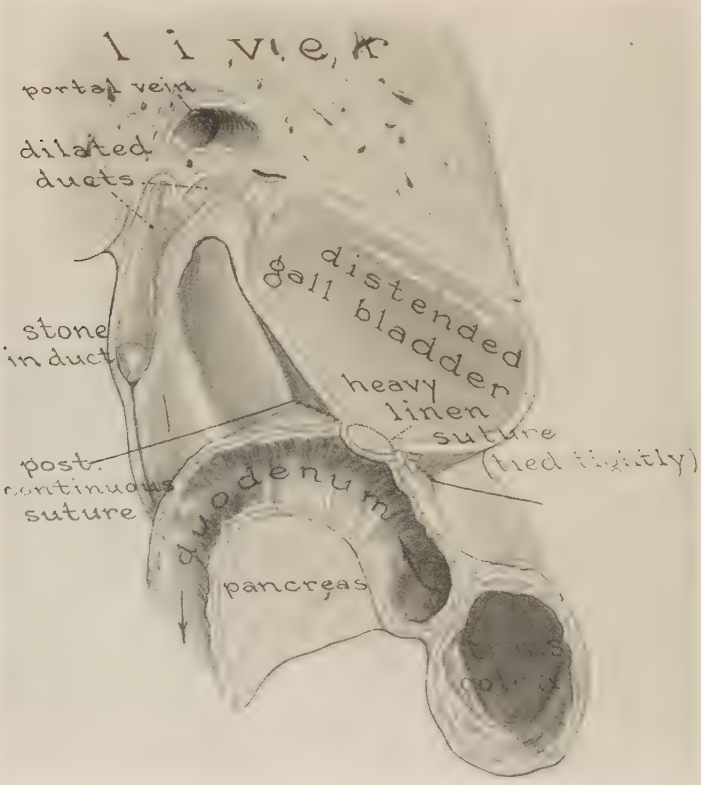


Fig. 909.—Ligature anastomosis, cholecystoduodenostomy for gradual decompression of distended gall-bladder in jaundice.

In operating for biliary disease one should be guided, not only by the age and resistance of the patient, but by the facilities and ability of the operator. The inexperienced operator, the operator with poor assistance, poor light, and poor exposure of the operative field, had better do a relatively safe and easy cholecystostomy than a dangerous cholecystectomy. Cholecystectomy is an operation for the expert surgeon operating, under ideal conditions, upon a patient in fair general condition, who is not toxic or jaundiced. With cholecystectomy there is danger of accidental injury to ducts and blood-vessels. Accidental ligation or incision of the common or hepatic duct, over-

looked stones in the ducts, and secondary leakage of bile or blood into the abdominal cavity after operation have caused many unnecessary deaths.

With an **external biliary fistula** there is waste of pigment for hemoglobin formation, loss of calcium with its influence on blood-clotting and on the hardening of bone, and an increased tendency to tetany, loss of sodium salts with impaired digestion, and waste of fat and of ingested calcium. In the absence of normal alkali, the calcium of the food combines with the fatty acids in the intestines, forming an insoluble calcium-soap, so that both the fat and calcium are lost to the body. Normally calcium is held in combination by the bilirubin of the bile. There is also loss of fluid (dehydration). Therefore, the patient with a chronic external biliary fistula, like the patient with chronic jaundice, often is a poor operative risk.

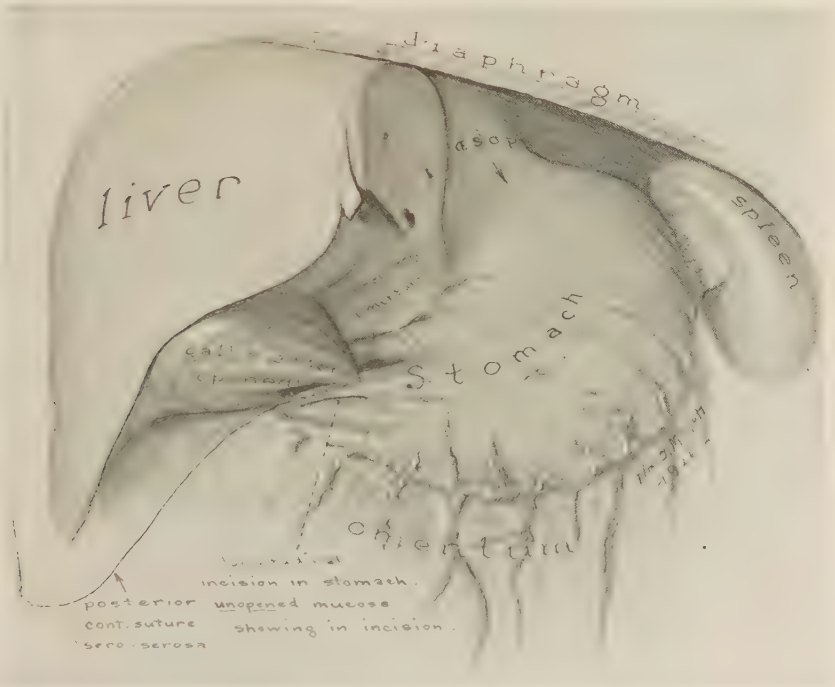


Fig. 910.—Cholecystogastrostomy for chronic obstructive jaundice by the ligature method to produce slow decompression of gall-bladder.

Summary of Operations for:

A. *Cholecystitis:*

1. Chronic or subacute—*cholecystostomy.*
2. With stone—*cholecystectomy.*
3. Purulent or gangrenous:
   a. In the young with good resistance—*cholecystectomy* or *cholecystostomy.*
   b. In the old with poor resistance—*cholecystostomy.*
   c. With advanced degenerative change in liver—*cholecystostomy* and prolonged drainage.

B. *Common Duct Obstruction:*

1. With slight jaundice—*choledochostomy.*
2. With intense jaundice—*cholecystogastrostomy* (never cholecystectomy), gradual decompression of liver, removal of stones if required later.

C. *External Biliary Fistula:*

1. Liberation of the fistulous tube and anastomosis to the stomach or duodenum.
2. Reconstruction and suture of ducts over rubber tube.
3. Hepatogastrostomy.

D. *Recurrent Colic After Cholecystectomy:*

1. Exploration; removal of stones or other obstruction.
2. Prolonged drainage of the common duct.

Drainage is used whenever postoperative leakage of bile or oozing of blood is feared.

BILE-DUCTS

Anomalies of the Bile-ducts.—Anomalies of the biliary ducts and vessels are common. In 75 per cent. the cystic duct enters the common duct at an acute angle, but it may run parallel with and attach to the common duct for

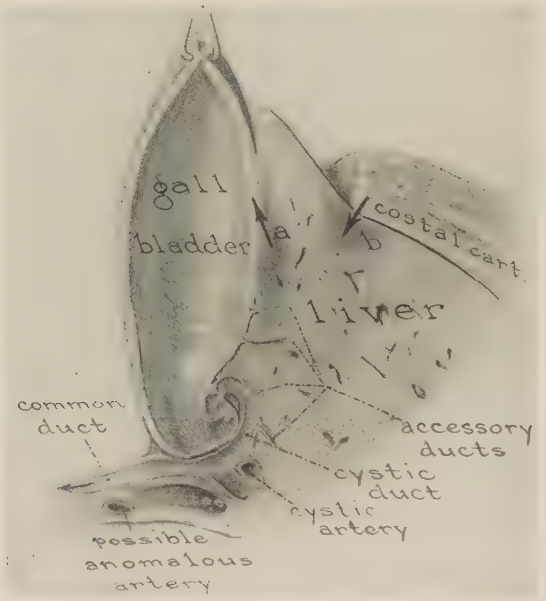


Fig. 911.—Section of gall-bladder and liver showing structures subject to injury during operation upon the gall-bladder: (*a*) Division of accessory duct entering gall-bladder or cystic duct. (*b*) Injury of liver from pressure against the costal arch during operation. (*c*) Adjacent common duct which may be divided in mistake for cystic duct due to overhang of neck of gall-bladder. (*d*) Anomalous artery, portal vein, cystic artery, which may be the seat of hemorrhage.

2 cm. or more, and twist in front of or behind the communis (Eisendrath). Accessory hepatic ducts, when present, open into the common, the cystic duct, or gall-bladder. The common duct may be double.

The cystic artery is double in 12 per cent. of the patients, and may not arise from the right hepatic artery but as a branch of the gastroduodenal, which may cross in front of the common duct. The right hepatic artery may lie behind the hepatic duct, the cystic artery arising just beyond the duct in 70 per cent. In 12 per cent. the right hepatic artery passes in front of the right hepatic duct, and in 10 per cent. runs parallel to the cystic duct close to the neck of the gall-bladder before entering the liver, where it may encircle the right hepatic duct.

Injuries to bile-ducts are especially common during cholecystectomy, the hepatic or common ducts being accidentally incised or divided, with peritonitis or secondary fistula to the surface. Stricture or stenosis is characterized by recurrent attacks of colic, with jaundice, fever, and chills. The duct wall may

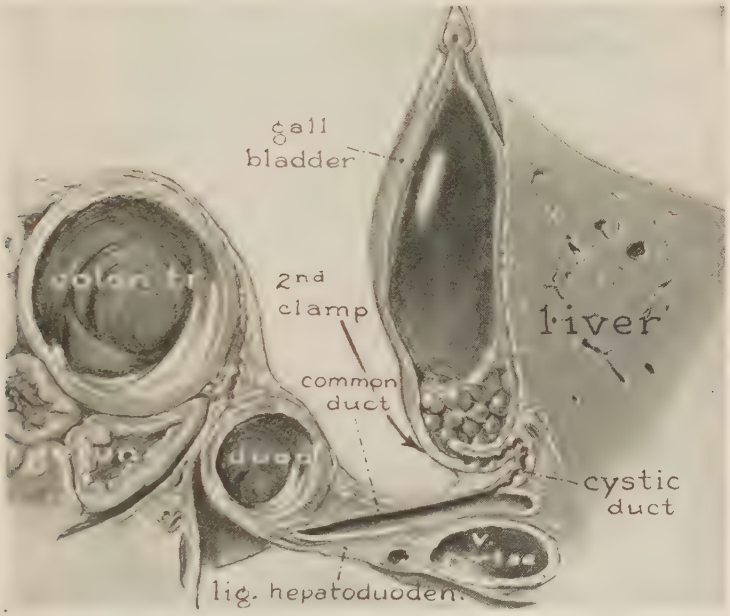


Fig. 912.—Cholecystectomy: A forceps, which apparently grasps the overhanging lower portion of the gall-bladder, frequently has instead the beginning of the cystic duct. If the lower end of the gall-bladder is not carefully raised and closely followed, it is quite easy to damage the common bile-duct.

slough from the pressure of retained clamps, drainage-tubes, or the strangulation from sutures or ligatures. The ducts may be lacerated or divided from blow or crushing injuries to the abdomen.

Symptoms from traumatic stricture occasionally subside under the use of bile-salts, diet, salicylates, and methylenamin.

Operative treatment consists of: 1. End-to-end suture with or without the introduction of a simple or T tube of soft rubber.

2. Division or excision of stricture, with reconstruction or re-formation of the duct from adjacent tissues, over a retained tube.

3. Hepaticoduodenostomy with (a) implantation of remains of common or hepatic ducts into duodenum, stomach, jejunum, or a segregated loop of bowel,

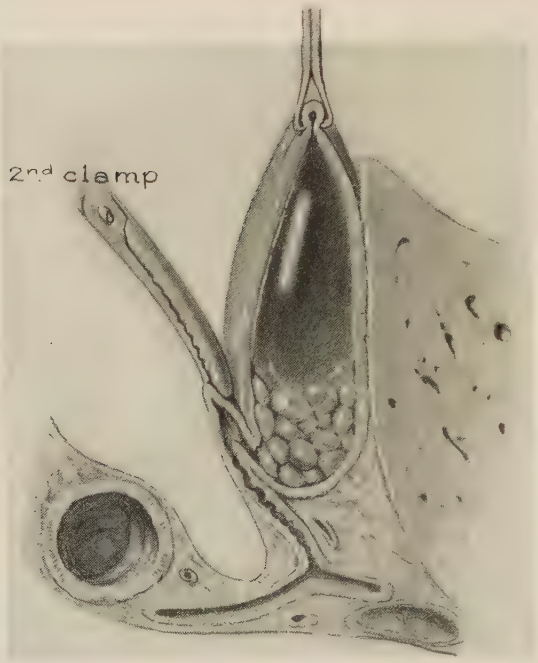


Fig. 913.—Cholecystectomy: Exposure for ligation of cystic duct by raising neck of gall-bladder.

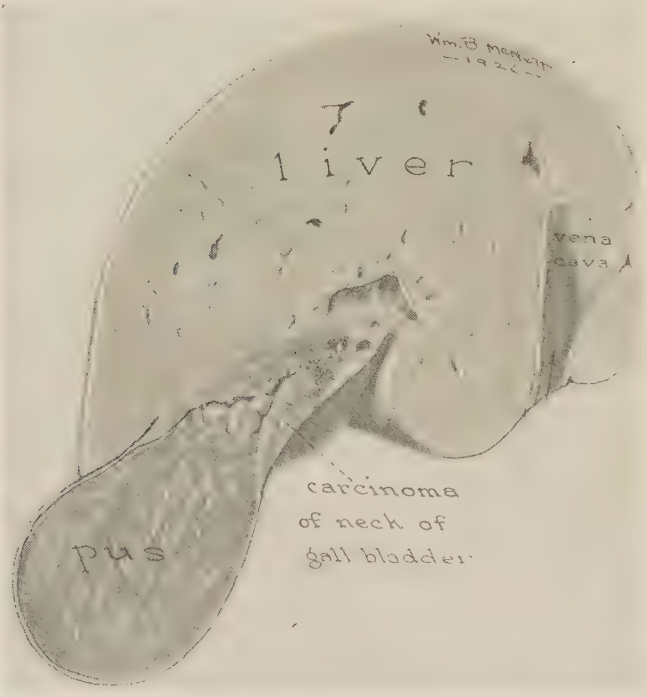


Fig. 914.—Carcinoma of the neck of the gall-bladder with pus-filled gall-bladder. Pus is often found with cancerous obstruction.

or (b) with a partial reconstruction of the duct from a flap made of duodenal wall, or (c) the suture of the edges of an opening in the duodenum or stomach to the capsule of the liver about the biliary opening.

4. Liberation of external sinus as a tube without destroying its blood-supply by too free liberation from the liver, and the implantation of the end of the sinus into the duodenum or stomach.

5. Cholecystenterostomy or cholecystogastrostomy with ligation of the ends of divided common duct.

Choledochitis.—Inflammation of the gall-ducts results from the same causes as those producing cholecystitis. The biliary radicles, the hepatic, common, or cystic duct may be involved, with thickening, dilatation, or occlusion.

Symptoms depend upon the degree of obstruction to the flow of the bile and the associated changes in the liver.

Treatment is that of the underlying cause.

Choledocholithiasis.—Stones in the biliary ducts resemble in composition those of the gall-bladder, from which usually they are derived.

Symptoms result from the sudden obstruction to the flow of bile (*duct colic*) and inflammatory changes in the ducts and liver. *Symptoms from obstruction of:* (1) The *cysticus* are the same as those from obstruction at the neck of the gall-bladder; 2 the *hepaticus*, slight or moderate jaundice with reduction in the amount of bile entering the intestine; (3) the *communis*, intense jaundice with absence of bile from the intestine, violent colic in the right hypochondrium with pain radiating to the back and right scapula; and *Charcot's intermittent fever*—chills, fever, sweat, followed in twelve to thirty-six hours by the jaundice.

Diagnosis. Jaundice from cancer, choledochitis, pancreatic enlargement is relatively painless, usually continuous and complete. A stone lodged in the common duct causes violent colic, followed by jaundice, rarely continued over ten days, often with intermittent, clay-colored stools, and bile-stained urine.

Courvoisier's Law.—Jaundice with enlarged palpable gall-bladder indicates cancer, while jaundice with contracted, thickened gall-bladder that cannot be felt accompanies stones of the common duct in 80 per cent. of the cases.

Treatment.—Choledocholithotomy or, for the very ill patient, cholecystenterostomy. A low choledochotomy may be *retroduodenal*, the duodenum being reflected to the left, or *transduodenal*, the ampulla being exposed by an incision through the anterior wall of the duodenum.

Cancer of the Bile-ducts. Columnar-celled carcinoma usually starts in the duodenal part of the common bile-duct, causes obstruction and jaundice, and invades the adjacent pancreas and duodenum. The growth in the early stages is but a few centimeters in diameter.

Etiology.—Age fifty to sixty-five, males slightly preponderating. Gall-stones are present in 30 per cent. of the cases. A growth situated near the ampulla causes obstruction and distention of bile-ducts, marked enlargement of the gall-bladder and liver, progressive relatively painless jaundice, cachexia, anorexia, cholemia, and delirium. Death occurs from intense cholemia, a suppurative cholangitis complicated by portal thrombosis, rupture of the distended gall-bladder, or hemorrhage. The patient seldom lives more than three to six months after jaundice develops; excision or cholecystenterostomy is indicated.

CHAPTER LIII

THE PANCREAS

PHYSIOLOGY.—The pancreas has an internal glycolytic secretion (*insulin*), formed in the islands of Langerhans, and essential for the proper metabolism and storage of carbohydrates. The pancreatic juice (500 to 800 c.c. daily) is discharged into the duodenum by the ducts of Santorini and Wirsung, and contains: Trypsin, a proteolytic ferment; amylase or amylopsin, an amylolytic ferment; lipase or steapsin, a lipolytic or fat-splitting ferment; possibly a rennin or milk-curdling ferment; maltase, and in suckling or milk-fed animals lactase. Trypsin is activated by enterokinase derived from the upper part of the small intestine; lipase is activated by admixture with bile. The pancreas is deeply placed and well protected from injury. It is well supported, and rarely becomes loose or enters a hernial sac. The main duct, that of Wirsung, enters the ampulla of Vater with the common bile-duct. The accessory duct of Santorini usually has an independent opening into the duodenum. In 90 per cent. of the cases the two ducts communicate, in 10 per cent. the duct of Santorini is the main duct. In 60 per cent. the common bile-duct grooves or tunnels the head of the pancreas, so that it may be pressed upon or occluded when swelling of the pancreas occurs (Mayo-Robson).

General Symptoms of Pancreatic Disease.—Deficiency or absence of the internal secretion (*insulin*) is shown by *glycosuria*, a high blood-sugar curve (*hyperglycemia*, over 100), and a lowered carbohydrate tolerance. The digestive symptoms of deficiency of one or more of the pancreatic ferments include: (a) *Steatorrhea* (fatty diarrhea)—the stools are bulky, frothy, oily, light colored, show an excess of undigested fat, and a relative excess of neutral fat in the form of droplets, fatty-acid crystals, and soap crystals. The bile aids the absorption of split fat, its absence being associated with an excess of split fat in the stools. Excess of fat and split fat, *i. e.*, fatty acids and soap, is also found in the stools from excessive fat-feeding, in jaundice, and in enteritis with diarrhea. (b) *Azotorrhea*—excess of protein and undigested meat-fibers in the stools above the normal 5 per cent.; is also increased in diarrhea, and can be reduced by constipation. (c) *Sialorrhea*—an excess of pancreatic secretion, analogous to the salivation of the salivary glands, is rarely observed. (d) *Diarrhea*—due to imperfect digestion and excessive fermentation from lack of pancreatic secretion. (e) *Dyspepsia* (quite common) is characterized by the usual symptoms of anorexia, distress, fulness after meals, heart-burn, nausea, and a special distaste for fats and meats. (f) *Emaciation* results from the improper assimilation of food. (g) *Nausea* and vomiting occur with the more marked forms of pancreatic disease.

Physical Signs.—A mass from an enlarged pancreas may be felt in epigastrium behind the stomach or gastrohepatic omentum. From acute inflammation, fever, sharp pain, tenderness, rigidity, and evidence of pressure on adjacent

organs occur. If jaundice is present, as from pressure on the common bile-duct, the clotting-time is longer, and the tendency to hemorrhage greater than in simple jaundice. The *Cammidge reaction* (fine yellow crystals when the urine is boiled with phenylhydrazin after oxidation) is suggestive only.

Symptoms Artificially Produced.—Alimentary glycosuria by the administration of 2 or 3 ounces of sugar before breakfast. Reduction in diastatic activities is determined by the diastase in the urine and stools. Disturbance of the sympathetic system, as shown by hyperthyroidism or Loewi's epinephrin mydriasis-reaction. Two drops of a 1 : 1000 solution of adrenalin in the conjunctiva are said to dilate the pupil within one-half hour in pancreatic insufficiency.

Traumatic Injury.—Contusion, laceration, or rupture of the pancreas result from a blow or compression of the pancreas between the abdominal wall and the spine. Serious hemorrhage, necrosis, acute pancreatitis, or violent peritonitis may follow and be fatal; or a cyst of the pancreas or of the lesser peritoneal cavity (*false* or *traumatic pancreatic cyst*) may result. Open wounds and gunshot injuries involving the pancreas have increased danger, as in the case of President McKinley, from the peritonitis caused by the escape of pancreatic secretion. The pancreas is often incised or slightly resected by the surgeon during a splenectomy and partial gastrectomy without ill-effect.

Treatment.—Wounds of the pancreas should be treated by prompt exploration, suture, packing or draining, to protect the adjacent tissues from the erosive pancreatic secretion.

Acute Pancreatitis (Fitz, 1899).—*Varieties* according to the predominant lesion: (1) Acute hemorrhagic pancreatitis; (2) acute gangrenous pancreatitis; (3) acute suppurative pancreatitis which may be diffuse or local (local abscess).

Pathology.—With the obstruction of the ampulla of Vater by gall-stones bile or duodenal contents enter the pancreatic ducts and activate the pancreatic ferments, which attack the gland with: (1) Hemorrhage from erosion of blood-vessels; (2) gangrene from thrombosis of blood-vessels; and (3) suppuration from coincident infection; (4) fat-necrosis from liberation of fat-splitting ferment. The hemorrhage, necrosis, inflammation, and suppuration are usually more or less associated. The pancreas may be largely destroyed in a few hours, with the formation of large sloughs.

From the passage of fat-splitting ferments into the blood, fat-necrosis occurs within a few hours in the pancreatic tissue, and fat of the mesentery, omentum and intestine, forming opaque, chalky, sharply defined spots, a few millimeters in diameter. They resemble miliary tubercles, but are not raised or nodular.

Etiology.—Acute pancreatitis usually follows chronic cholelithiasis. It is most common in adult males. Other causes of pancreatic hemorrhage are: (1) Vascular disease such as atheroma; syphilis, and alcoholic excess; (2) trauma; (3) fatty degeneration of the gland; (4) fat-necrosis from liberated pancreatic ferment, from injury, the disintegration of neoplasm, or embolism of the pancreatic artery, and (5) heart, lung, liver disease, scurvy, purpura, exanthemata, phosphorous poisoning, and chronic pancreatitis.

Symptoms.—The onset is sudden and of great violence, with agonizing pain, shock, pallor, coldness of the skin, subnormal temperature, rapid weak pulse, and vomiting of the contents of the stomach and of bile. The pain is so ex-

cruciating that repeated large doses of morphin are required. Jaundice often appears early. The abdomen becomes distended, with evidence of free fluid and peritonitis, and there is increased resistance in the left upper abdomen. On opening the abdomen, grayish spots of fat-necrosis are found on the mesentery or omentum, and a watery, slightly blood-stained or "beef-broth" exudate.

Diagnosis.—The condition resembles a gall-bladder colic of superlative degree. An acute abdominal attack with pain so severe that it causes shock in a person who has had preceding biliary attacks, and who shows abdominal distention, the presence of free fluid in the peritoneum, and resistance or mass in the upper left abdomen and epigastrium, is very suggestive. At times a differentiation from perforated gastric or duodenal ulcer, gall-stones, or acute intestinal obstruction is difficult.

Prognosis.—Acute pancreatic hemorrhage or pancreatic apoplexy is often fatal in from a few hours to seven days. Where there is less destructive hemorrhage or necrosis, the patient may live days or weeks without operation, or even recover. The mortality is about 80 per cent. in the severe gangrenous and hemorrhagic forms, 10 per cent. in the less destructive types.

Treatment.—Immediate operation to evacuate pancreatic fluid, clots, and necrotic masses, and to decrease the pressure of bile in the ampulla of Vater.

Operation.—This consists of a right vertical transrectus incision. 1. If the pancreas is enlarged but not necrotic, with widespread fat-necrosis over the peritoneum and free "beef-broth" exudate, a cholecystostomy or cholecystogastrostomy is done and the peritoneum drained by tube or cigarette-drain. The pancreas is not disturbed. The patient is often too ill for exploration or removal of a stone from the ampulla.

2. If the pancreas is hemorrhagic and slightly necrotic, gauze drains are carried to the overlying peritoneum, but the pancreas is not explored.

3. If the pancreas is necrotic, hemorrhagic or suppurating, the adjacent peritoneal cavity is temporarily walled off by gauze packs, the gastrocolic omentum incised, clots, pus, and necrotic sloughs evacuated, dependent drainage obtained by gauze and tube introduced through an incision in the left costovertebral angle, the opening in the gastrocolic omentum closed by suture, and the anterior wound closed around a tube or cigarette-drain carried to the gastrocolic suture line.

In the *after-treatment* calcium, glucose, and salt solution should freely be used intravenously, as after operation for biliary disease.

Abscess of the pancreas may be single or multiple.

Etiology.—Suppurative pancreatitis is due to obstruction of a pancreatic duct, as from pancreatic calculus; obstruction of the ampulla of Vater by stone, inflammation, or neoplasm; extension of a suppurative cholangitis; acute pancreatitis; extension of inflammatory process from the stomach or other viscus, or as a focal infection in septic or pyemic disease.

Symptoms.—(1) Epigastric tumor (often not palpable); (2) fever and leukocytosis; (3) epigastric tenderness and vomiting, and (4) jaundice; (5) glycosuria; (6) steatorrhea, often is absent.

Treatment.—Incision, evacuation, and drainage, with protection of the general peritoneal cavity.

Chronic Pancreatitis.—This occurs as an interlobar and interacinar pancreatitis, the latter involving the islands of Langerhans, producing hyperglycemia.

a *b* *c*

Fig. 915.—Peritoneal lesions from: *a*, Fat necrosis due to acute pancreatitis; *b*, miliary tuberculosis; *c*, metastatic carcinoma.

Chronic Interlobar Pancreatitis.—*Etiology:* This follows obstruction and inflammation of the pancreatic ducts from gall-stones, pancreatic calculi, extension from choledochitis and carcinoma, producing obstruction of the ducts.

Pathology.—The pancreas is hard and indurated, and has an excess of fibrous tissue between the lobules; the cells of the lobules and islands of Langerhans being affected only in the terminal stages of the disease. Gall-stones and cirrhosis of the liver are often associated.

Symptoms are indefinite, often suggesting gall-stones, with chronic dyspepsia, vomiting, tympany, recurrent colic, occasionally jaundice, rarely glycosuria, and the change in the feces from deficient pancreatic secretion.

Treatment.—Removal of pancreatic or biliary calculi, prolonged biliary drainage by cholecystostomy or choledochostomy and, if jaundice is present without stones, a cholecystoduodenostomy is indicated.

Chronic Interacinar Pancreatitis.—A diffuse fibrosis of the acini, with early degeneration of the islands of Langerhans, hyperglycemia and glycosuria.

Symptoms are those of diabetes.

Treatment.—Symptomatic, with removal of gall-stones if these are present, and prolonged drainage of the gall-bladder if there is biliary infection.

Pancreatic calculi are usually small, multiple, and of an opaque white color. They consist of phosphate or carbonate of lime, and are found in the pancreatic ducts which become dilated from back pressure. A secondary chronic interstitial pancreatitis or an acute abscess may follow.

Symptoms.—Recurrent epigastric colic radiating to the left side of the chest and the scapula, with vomiting and chills and, occasionally, jaundice, wasting, fatty diarrhea, and rarely hyperglycemia and glycosuria.

Treatment.—Pancreaticodochotomy and docholithotomy. The enlarged duct is exposed usually through the gastrocolic omentum, incised, the stones removed, and the duct and the pancreas sutured. A provisional cigarette-drain is carried to the pancreas to guard against leakage.

Pancreatic Cysts. Varieties: (1) *Retention cysts (pancreatic ranula)* are the most common and are rarely large. They follow obstruction of the large or small pancreatic ducts, as from calculus, ligature, a chronic interstitial pancreatitis, or as a sequel to an acute pancreatitis. (2) *Proliferative cysts (cystadenoma* or *cystadenocarcinoma)* are true tumors, and may be multilocular. At times they contain intracystic papillomatous growths and may be malignant or cancerous, change may develop in the wall of an apparently simple cyst. The cyst usually springs from the body of the pancreas, and may contain 15 to 20 liters of thick, viscid, dark fluid. (3) *Cystic disease*, similar to the congenital cysts of the kidney and liver occasionally involves the pancreas. (4) *Pseudocysts* from hemorrhage, autodigestion, and degeneration of the pancreas follow injury, acute hemorrhagic pancreatitis, or effusion into the lesser peritoneal sac. They have no true walls, and are limited by adherent adjacent organs. (5) *Parasitic cysts* and *hydatids* are rare.

Etiology.—*Age:* Between five and seventy-five years, but chiefly between twenty and fifty years. *Sex:* The traumatic form is more frequent in males, the non-traumatic in females. Acute and chronic *infections* of the pancreas are chiefly responsible, but a cystic carcinoma or adenoma may be present.

Symptoms are slowly enlarging epigastric tumor, with or without pain, digestive symptoms, and loss of flesh. The elastic mass occupies the midline, or lies to the left of the midline. It approaches the abdominal wall usually by: (1) Stretching the gastrocolic omentum and (2) the gastrohepatic omentum; (3) by separating the layers of the transverse mesocolon, or (4) by distending the transverse mesocolon below the transverse colon. The tumor is fixed, and does not move with the respirations.

Differential diagnosis is to be made from pregnancy, ovarian tumor; enlargement of the left kidney, liver, spleen, mesentery, and omentum. The point of origin, and the relation to the liver, stomach, and transverse colon are important.

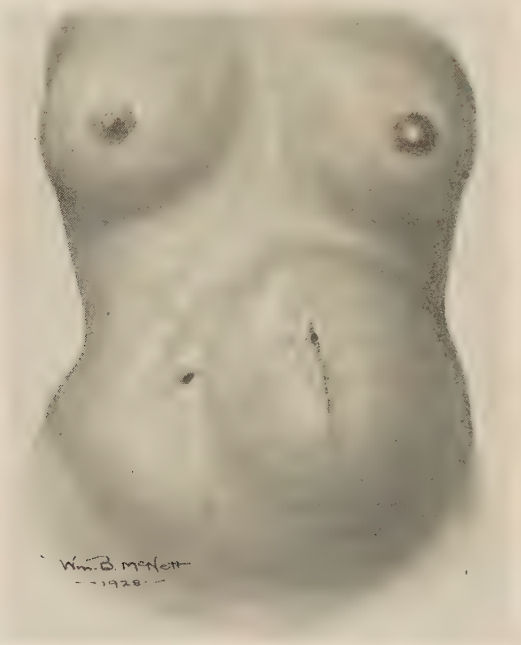


Fig. 916.—Pancreatic cyst in a woman aged twenty-nine, illustrating the danger of marsupialization in cysts of the pancreas. Cyst incised and drained March, 1922; persistent suppuration and refilling of sac. Reoperation May, 1925, excision of cyst and adjacent portion of pancreas; microscopic examination showing adenocarcinomatous change in the thin wall of the cyst, secondary abdominal metastasis, and death November, 1926.

Wohlgemuth's test is based on an increase of the diastatic value of the urine to D 38°/30 = 125 and above.

The prognosis is said to be unfavorable when the urinary diastase is above D 38°/30 = 1000.

A cystic retroperitoneal tumor in the upper abdomen is shown by palpation, percussion, inflation of the stomach and colon, and roentgenograms. Diastastic ferment may be found in the blood and urine, and undigested muscle-fibers in the stools by Gross-Carliss or Füller's method, or an excess of albumin by Schmidt's test. Pure fat stools are very rare. Diabetes or alimentary glycosuria is rare, even with large cysts. Loewi's and Cammidge's tests are unreliable. The cyst contents may show tryptic, diastatic, or lipolytic enzymes.

Treatment.—1. *Marsupialization:* The cyst is exposed, carefully sutured to the abdominal wall to avoid leakage into the peritoneal cavity, opened, evacuated, and drained. The cyst walls collapse, and the cavity may become obliterated. Not infrequently complete evacuation does not occur (multilocular cyst), or suppuration, reaccumulation, or evidence of malignancy later appears.

2. While *extirpation* is more difficult it is the preferred operation, and should be attempted, especially with proliferative cysts and malignant or echinococcus cysts.

Total extirpation of the cyst is followed by a mortality of 20 per cent. Incision with drainage has a mortality of 7.6 per cent., and is followed by persistent fistula in 15 per cent. The discharge from the fistula may be reduced by an anti-

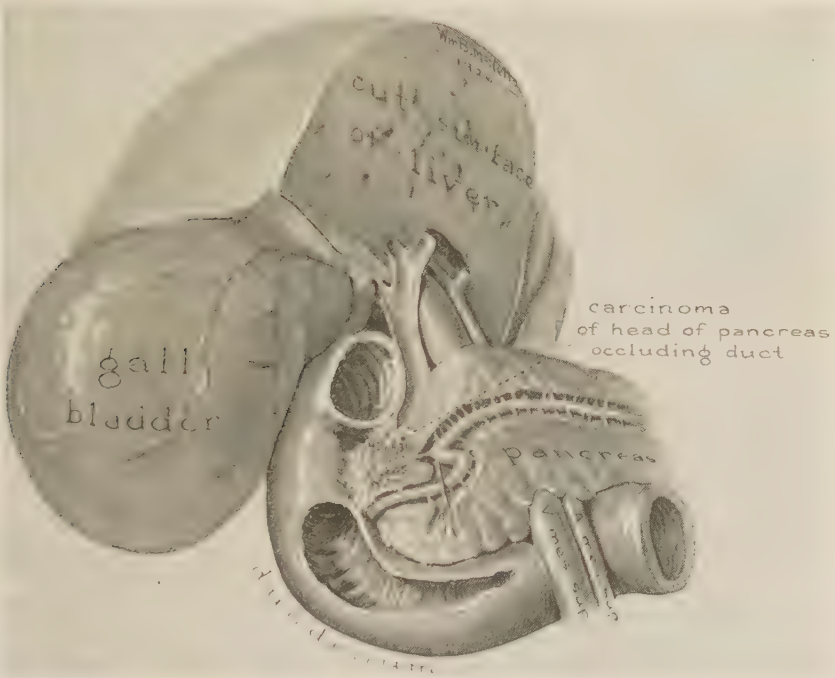


Fig. 917.—Distention of gall-bladder and biliary ducts from carcinoma of head of pancreas obstructing common duct.

diabetic diet, and the administration of bicarbonate of soda to neutralize the gastric juice. The fistulous tube has been successfully circumcised and implanted into the gall-bladder (Hammerfahr). A lumbar incision is useful in cysts of the tail of the pancreas, and a lumbar counterdrain often desirable after any of the operations on the pancreas.

Tumors of the Pancreas.—*Carcinoma* is the most common tumor and chiefly arises from the head of the pancreas. *Sarcoma* and *adenoma* are rare.

Carcinoma usually is columnar-celled or scirrhous, but may be encephaloid or colloid. It obstructs the common bile-duct, and invades the duodenum, stomach, and other adjacent organs. The pancreas is frequently infiltrated by a carcinoma originating in the stomach, gall-bladder, or bile-ducts.

Symptoms.—Jaundice with progressive enlargement of the gall-bladder (law of Courvoisier), emaciation, indigestion, nausea and vomiting, copious fat stools containing undigested fat and muscle-fiber or other evidence of interference with the pancreatic secretion. The tumor is only occasionally palpable. Duodenal obstruction may occur later. Frequently there is abdominal distress and moderate fever, but not the violent pain of gall-stone colic.

Diagnosis.—Progressively increasing jaundice, without biliary colic and with enlargement of the gall-bladder, in a middle-aged or elderly person, is suggestive of pancreatic carcinoma. The jaundice is persistent and complete, so that the stools are constantly putty colored and the urine dark. The bile is also stained. The diagnosis is rarely made early enough for surgical extirpation.

Treatment.—In the early stages, if the head of the pancreas is involved, this may be amputated, the vessels ligated, and the pancreatic stump with the open ducts carefully sutured into an opening made in the side of the duodenum. If it is necessary also to resect a segment of the duodenum, the stump of the pancreas may be inserted into the end of the duodenum, a gastro-enterostomy done, the common bile-duct ligated below the cysticus, and the gall-bladder anastomosed to the stomach or duodenum. Upward of three-fourths of the pancreas may be removed. By insulin feeding, life may be preserved for a considerable period of time after complete extirpation of the pancreas in lower animals. Resection of the tail of the pancreas is not especially dangerous, and often inadvertently occurs in the removal of the spleen.

CHAPTER LIV

THE SPLEEN

Congenital Anomalies.—Congenital absence of the spleen is very rare. Accessory spleens, small oval or rounded masses from 1 to 3 cm. in diameter, are frequently found in the gastrosplenic or great omentum, rarely causing symptoms.

Functions of the spleen include:

(1) Formation of erythrocytes in the embryo; (2) destruction of imperfect, immature, or dead red cells after birth; (3) formation of lymphocytes; (4) filter for the removal of bacteria and toxins from the blood. The bacteria or toxic products may be passed on to the liver for a final disposition.

Removal of the normal spleen results in: (1) A polymorphonuclear leukocytosis; followed by (2) a relative lymphocytosis; (3) a temporary anemia with reduction in the number of red cells and the amount of hemoglobin; (4) a hyperplasia of the other elements of the reticulo-endothelial system and, possibly, (5) an increased susceptibility to infection.

Removal of the diseased spleen is followed in certain cases by: 1. Increase in the amount of hemoglobin and of red cells, the defective or imperfect red cells previously destroyed by the spleen now being preserved.

2. Reduction in the portal blood-stream, as 20 per cent. or more of the portal blood entering the liver comes from the spleen. In splenomegaly a much larger percentage of the portal blood may be splenic, therefore, in portal cirrhosis of the liver, the strain upon the constricted vessels is reduced and ascites may disappear after splenectomy.

3. Relief from hepatic toxemia. The normal spleen acts upon toxic substances, and then passes them on to the liver for final disposition. The diseased spleen may generate toxic substances, or pass imperfectly metabolized and therefore unduly toxic substances to the liver, which undergoes cirrhotic or other degenerative change as a result. These secondary changes in the liver may be relieved by splenectomy.

4. Jaundice from the excessive destruction of red blood-cells in the spleen may be relieved by splenectomy.

5. Polycythemia, as in polycythemia vera, may disappear after removal of the spleen.

6. Clotting time. If the diseased spleen removes not only worn-out red cells but also the platelets, greatly prolonged clotting time and a tendency to hemorrhage results, as in purpura. Splenectomy in chronic purpura enables the platelets to be preserved.

7. Anemia. An excessive destruction of erythrocytes tending to chronic anemia and death may, in certain cases, be arrested by splenectomy.

Diseases of the spleen, therefore, are frequently associated with cirrhosis of the liver, an excess of white cells, decrease in the platelets, a tendency to

hemorrhage, an increased destruction of red blood-cells, and the production of anemia and jaundice.

Influence of Age and Toxemia.—After thirty (Gross) the capsule of the spleen undergoes hyaline change, the media and adventitia of the blood-vessels thicken and become more fibrous and hyaline, the malpighian arterioles and capillaries being thicker and increased in number. Reduction in lymphoid tissue, decrease of pulp, and fragility tend to progress from birth.

In acute general infections the spleen enlarges, becomes red, with an increase of the protoplasmic pulp-cells and a predominance of large mononuclear cells; or gray, with an increase in polymorphonuclear cells, pulp-cells, and endothelial cells.

Movable Spleen (Wandering Spleen; Floating Spleen; Ptosed Spleen, or Splenoptosis).—*Etiology:* (1) Relaxation of the abdominal walls (Glénard's disease); (2) congenital or acquired elongation of the supporting peritoneal folds; (3) enlargement of the spleen.

Positions Acquired: (1) Left iliac fossa; (2) floor of the pelvis behind the uterus; (3) any region of the abdomen; (4) ventral or inguinal hernial sac. The mobile spleen may rotate on its axis with torsion, obstruction, hemorrhage, or thrombosis of the splenic vessels. Enlargement from engorgement or necrosis of the spleen, and firm adhesions to other organs may result. When fixed in an abnormal position by adhesions, the spleen is said to be dislocated. The shape of the spleen with its peculiar notch is of value in the diagnosis.

Treatment.—If secondary hemorrhage, degeneration, or cyst formation has occurred in the spleen, a splenectomy should be done. If the spleen is merely displaced and not seriously diseased, splenopexy may be carried out by a transverse incision through the peritoneum in the lumbar region, with separation of the adjacent peritoneum from the overlying structures of the abdominal wall so as to form a pocket into which the spleen is placed (*Rydygier's operation*), the opening in the pocket being finally narrowed by sutures without constriction of the pedicle.

Injuries of the Spleen.—The spleen is very vascular, often soft, brittle, and easily ruptured, lacerated or pulpefied by injuries with or without division of the abdominal wall. This is particularly true when the spleen is enlarged and brittle from malaria, typhoid, kala-azar, Malta fever, relapsing fever, and the like, rupture following a slight kick or blow, or even palpation of the organ. Rarely there is rupture of the splenic pedicle. Wohl collected 28 cases of spontaneous rupture of a previously healthy spleen during an acute illness, fourteen occurring during typhoid fever.

Symptoms are those of intra-abdominal hemorrhage. Usually they follow an injury over the upper left quadrant of the abdomen, and are associated with pain which may radiate to the left scapula, a tender indefinite mass, rigidity of the overlying abdominal wall, shifting dulness, shock.

The hemorrhage may be: (a) *Violent*, and result in death in from a few minutes to an hour; (b) *progressive*, the patient being able to walk perhaps half a mile, exsanguination and death following in from three to forty-eight hours; (c) *recurrent*, repeated, moderate hemorrhages occur, usually with violent pain after movement or exertion, and at intervals of one or more days.

Punctured or penetrating wounds may result from the end of a broken rib, knife, bullet, or other object. Usually these wounds are followed by a rapidly fatal hemorrhage if not treated; rarely there is little bleeding.

Prolapse of the spleen, with or without laceration and rupture, may occur through an extensive wound in the abdominal wall.

Treatment.—Gentleness should be used in palpating the spleen during acute infections, especially in patients over thirty-five years of age. After rupture, immediate operation as a rule is necessary to prevent death from hemorrhage. Suture of the spleen is rarely practicable on account of the softness of the organ. Small fissured wounds or openings of the spleen may be controlled by a firm gauze-packing. If the spleen is extensively lacerated or pulpefied, splenectomy should be done, or a clamp may be applied to the splenic pedicle, packing introduced, and the spleen removed after several days. An associated transfusion of blood may be life-saving. A prolapsed spleen usually is best treated by removal.

Splenomegaly.—Enlargement of the spleen is suggested by a superficial mass with a rounded edge, moving with respiration, projecting from under the left ninth rib and costal cartilage, having a smooth surface, a sharp notch in the medial border, and dulness in front continuous with a thoracic dulness, underlying the ninth, tenth, and eleventh ribs. The mass differs from that of the kidney in that a projecting mass with dulness in the loin is absent, and the inflated colon lies below and mesial to the mass, and not anterior to it as with the kidney.

Abscess of the spleen is rare except as a secondary metastatic embolic process, from endocarditis, in pyemia or other acute pyogenic infections. The pus may rupture into the peritoneum, through the diaphragm, or the abdominal wall.

Symptoms are chill, fever, sweat, with rapid enlargement and tenderness over the spleen, and rigidity of the overlying abdominal wall.

Treatment.—If localizing adhesions have formed, evacuation and drainage should be used; if the spleen is not adherent, splenectomy may be done. An exploring needle should be used only when the spleen is adherent to overlying structures.

The **prognosis** of typhoid abscess usually is favorable. If the abscess is part of the general pyemic process, operation usually is futile except as a possible palliative measure.

Infarction occurs in the spleen more frequently than in any other organ except the kidney, frequently from endocarditis, occasionally from displaced portions of thrombi, in typhoid or other specific fevers. The infarcts are usually multiple, and may be red or white.

Symptoms are the rapid enlargement of the spleen, with pain and tenderness in the left upper quadrant of the abdomen, associated with fever, leukocytosis, and peritoneal reaction.

Diagnosis.—The sudden painful enlargement of the spleen, during the course of endocarditis or other thrombic or embolic process, suggests infarction.

Treatment, as a rule, is rest and palliation. With an occasional patient the local distress is so great that removal of the spleen or drainage of a secondary abscess is requested.

Tuberculosis often involves the spleen in childhood as a part of widespread or miliary tuberculous process. With the more unusual condition of tuberculosis limited to the spleen, splenectomy has been followed by recovery.

Syphilis.—Chronic syphilis associated with marked anemia and splenomegaly may be relieved by splenectomy, the resistance to salvarsan and other antisyphilitic treatment disappearing after the operation. Gummata of the spleen are rare and seldom justify operation.

Splenic anemia (*Banti's disease, primary splenomegaly*) usually occurs in males in late childhood or early adult life, and is characterized by enlargement of the spleen, anemia, and recurrent hemorrhages. The spleen is large, firm, thick, often adherent, shows much fibrosis; and there is tendency for enlargement of the splenic, portal, and esophageal veins. Later the liver may show passive congestion, an intense atrophic interlobular cirrhosis (*Banti's disease*), with marked contraction and final ascites.

Symptoms usually develop with a slowly advancing anemia of the secondary type, a leukopenia, and a relative lymphocytosis. The spleen is large, smooth, and painless, and is not associated with other changes in the reticuloendothelial system.

Treatment.—Splenectomy, which is best carried out in the early stages before anemia is intense, the cirrhosis of the liver marked, and before varicosities and severe hemorrhages and ascites have developed. The mortality from operation upon the late cases is about 10 per cent. In 13 per cent. hemorrhages, chiefly from the varicose esophageal veins, occur even years after operation, and may be fatal.

Hemolytic Icterus.—1. **Acholuric familial jaundice** (*congenital family cholemia, Chauffard-Minkowski type*) occurs in both sexes, usually in childhood, often in several individuals of the same family, or in successive generations. Occasionally sporadic cases occur.

Symptoms.—The spleen is enlarged, the jaundice is often slight, with absence of bile from the urine and presence in the blood-serum and stools. There is fragility of the red cells which are hemolyzed by sodium chlorid (0.7 per cent.) solution, whereas normal cells withstand 0.4 per cent. solution. The blood shows the usual secondary type of anemia. Crises occur with fever, exacerbation of the jaundice, increase in the size of the liver and spleen, malaise, but the patient may live to an age of fifty or sixty.

2. **Acquired type** (*Hayem-Widal type*) occurs in adolescent life, and has a more rapid course. Pigmented gall-stones are formed in 60 per cent. as a result of the constant excess of bile-pigment from the continued hemolysis, and may give rise to confusing associated biliary obstructive symptoms.

Treatment.—Splenectomy gives excellent results, with a mortality of about 6 per cent. (Mayo). Operation is not warranted where the symptoms are mild and the general health not seriously disturbed. For the acquired type, which runs a more rapid course and may be fatal from anemia or intercurrent disease within a few years, splenectomy is more strongly indicated. After splenectomy the anemia and the jaundice rapidly disappear.

Chronic splenic anemia of children (*von Jaksch's anemia*) develops in infants a few months old and in young children, with enlargement of the spleen

and liver, marked anemia, the red cells being reduced to 1,000,000 or 2,000,000 per cubic millimeter, the hemoglobin to 10 or 40 per cent. A leukocytosis of 20,000 to 40,000 is usual, at times with a lymphocytosis, but occasionally there is leukopenia. Normoblasts and megaloblasts occur in large numbers, with many (10 to 25 per cent.) myelocytes.

Prognosis is bad, with few complete recoveries. If the patient lives, the condition may merge into that of the splenic anemia of adults.

Treatment.—While splenectomy has a high mortality, it should be considered for this very serious condition.

Pernicious Anemia.—A striking transient benefit may follow the removal of the spleen in pernicious anemia, the duration of life, which is usually about two years, is prolonged to five years in 22 per cent. of the cases and in 10 per cent. for a longer period (Mayo). If the patient is properly prepared for operation by repeated blood-transfusions, the mortality of the operation may be kept below 5 per cent. Splenectomy should not be used in the aplastic type, in terminal stages, in elderly patients, during a crisis or without first trying a diet of liver. It should be considered, however, for certain of the more chronic types and especially for pernicious anemia in young persons.

Treatment should include: 1. Removal of septic foci from other parts of the body, including teeth, tonsils, nasal sinuses, gall-bladder, appendix, fallopian tubes, and prostate.

2. Correction of anemia by one to four preliminary blood-transfusions. Repeated small transfusions are better than a single large one. As a rule 6 to 8 ounces of blood are given every seventh day; the splenectomy to be done two or three days after the last transfusion, as the transfused blood is rapidly destroyed.

3. Radiation of the spleen. The application of radium over the spleen reduces the size and activity of the organ, diminishing its hemolytic function. The area over the spleen should be blocked out in appropriate squares, and the radium carefully applied over each area. Harm may follow too prolonged or intense treatment, and the secondary fibrosis and adhesions which result may render a later operation difficult.

4. The free use of liver as a food. This often renders other treatment unnecessary, at least for a time.

Erythremia (*polycythemia rubra* or *vera*, *Vaquez's disease*, *Osler's disease*) is characterized by enlargement of the spleen and usually of the liver, an increase of the hemoglobin to 100 or 130, and an increase of erythrocytes to from 6,000,000 to 14,000,000. The condition tends to progress to gradual exhaustion, with hemorrhages. The course of the disease may apparently be arrested by splenectomy.

Purpura Hæmorrhagica.—In purpura the blood-platelets, normally from 225,000 to 400,000 per cubic millimeter, may be reduced to 10,000 (*thrombocytopenia*) and the clotting-time be prolonged from eight to forty-five minutes, with a non-retractile clot. Usually there is a moderate secondary anemia, and a normal or slightly elevated leukocyte count. There may be jaundice or hemolytic ictero-anemia. There is a positive *tourniquet* test, or ecchymosis following constriction of a limb.

Varieties.—(1) *Purpura fulminans* is a malignant form, fatal within a few hours, at times mistaken for acute leukemia; (2) *acute toxic form;* (3) *chronic form.*

Chronic purpura begins in adolescence, often in girls who have had poor health. The purpura is associated with severe constitutional disturbance and splenomegaly, and tends to intermittently progress. The onset may be abrupt after a few days of malaise, with severe and extensive ecchymosis, hemorrhages from mucous membranes, nose, gums, stomach, bladder, and uterus.

In *morbus maculosus* of Werlhof there is malaise at the onset followed in a few days by severe and extensive ecchymosis and hemorrhages, joint-pains, vomiting; nephritis and fever occur.

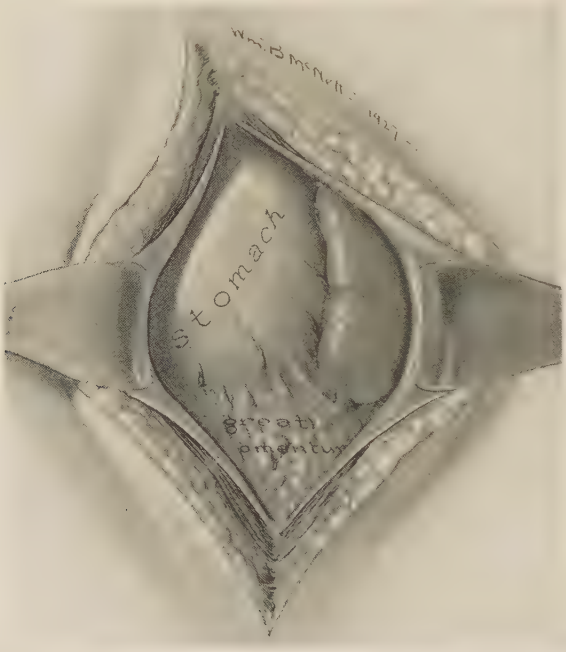


Fig. 918.—Splenectomy: Vertical left rectus incision with exposure of stomach and enlarged spleen.

In the acute types of purpura repeated blood-transfusions should be used. In the chronic form, besides blood-transfusions and "*protein-shock*" injections, the removal of the spleen should be considered, to prevent the destruction of the platelets. The platelets rapidly increase after splenectomy.

Splenomyelogenous Leukemia.—Primary splenectomy for this disease is usually fatal. Radium and the Roentgen ray afford temporary improvement but in two or three years lose their good effect, and the disease then rapidly progresses to a fatal issue. After first applying radium until the white cells have been reduced to about 30,000, however, splenectomy may be done with a mortality of about 3 per cent. (Mayo). The patients do not become normal, but the disease is arrested, the condition improved, and life is prolonged from one to eight years.

Gaucher's Disease.—A rare chronic disease, beginning in childhood, characterized by splenomegaly and the development in the spleen, liver, lymph-nodes, and bone-marrow of peculiar large cells with small nuclei.

Pathology.—The average weight of the spleen is 7 pounds, but may reach 14 pounds or more. Secondary enlargement of the liver appears late. Characteristic large cells with small nuclei are found in the dilated venous sinuses of the spleen, in the liver, lymph-nodes, and bone-marrow. The bone-marrow is soft and red. The body fat is retained. There is increased pigmentation and late in the disease the liver enlarges.

Etiology is obscure. Gaucher's spleen usually occurs before the age of twelve, in the female sex (86 per cent.); a familial tendency may be present.

Fig. 919.—Splenectomy: Delivery of the spleen through the abdominal incision.

Symptoms are enlargement of the spleen, pigmentation of the face, neck, and hands of a brownish-yellow color. Wedge-shaped yellowish thickenings of both sides of the cornea occur. Later ecchymosis and leukopenia, with an average of 3,700,000 red cells and 65 per cent. of hemoglobin, and finally an anemia of the chlorotic type.

Prognosis.—The average duration of life is nineteen years. There is little disturbance of the general health until late in the disease.

Treatment.—Splenectomy is usually advised, but the duration of the disease, the limited effect upon the general health, the possibility that splenectomy may not be curative, and the high mortality of the operation (20 per cent.) should be explained to the patient before operation is attempted. The chief object of the operation is the removal of the objectionable abdominal enlargement. The effect of preliminary radiation should be noted before resorting to operation.

Cysts of the spleen (rare) are usually due to the echinococcus. Hemorrhagic, serous, lymphatic, and dermoid cysts also occur.

The **treatment** is splenectomy.

Tumors of the Spleen.—Primary neoplasms of the spleen are rare. Sarcoma, the usual primary growth, forms a rapidly growing nodular tumor that often is very painful.

Treatment is splenectomy. The spleen is the frequent seat of secondary malignant growths, for which it is obvious that surgical treatment is not indicated.

Splenectomy may be performed through a long vertical upper left transrectus incision, or by a transverse or angled incision of the Donn or Perthes type. Rarely temporary resections of the eighth, ninth, and tenth costal cartilages have been added to give more room. The spleen is cautiously liberated and rotated down and out to give access to the large and fragile vessels of the pedicle, which with great care are double ligated, preferably individually. The tail of the pancreas frequently has been included in the ligature, and often this is followed by a febrile reaction, but without serious secondary changes. The stomach may be injured, or a thrombus extend from the ligated splenic vein into the superior or inferior mesenteric.

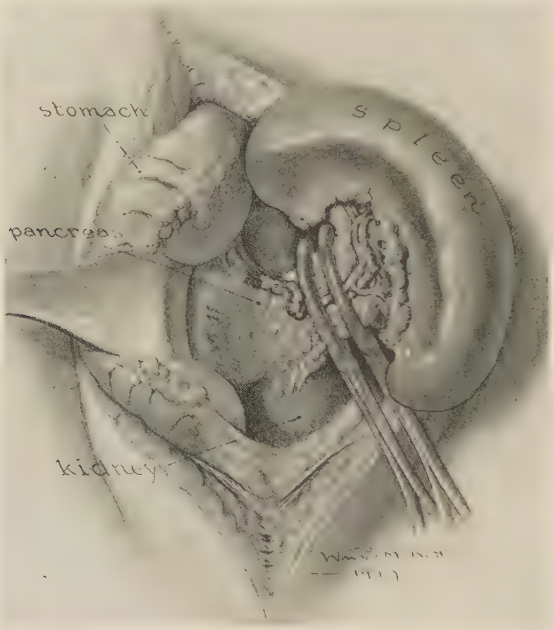


Fig. 920.—Splenectomy: Clamping the splenic pedicle preliminary to removal and to individual ligation of the splenic vessels. Great care is necessary if clamps are used to avoid laceration of the large veins.

The *mortality* for splenectomy varies from 2 to 30 per cent., depending upon the disease, the patient's condition, care in preoperative preparation, and the skill employed. In certain diseases of the spleen (as leukemia) preliminary radiation greatly reduces the mortality.

CHAPTER LV

HERNIA

Definition.—A *hernia*, *breach*, or *rupture* is the abnormal protrusion of a viscus through the parietes, the protruding part being covered by a sac. *Prolapse* refers to the escape of a viscus through an opening or wound, the protruding part not being covered by a preformed sac. Hernia, as a rule, applies to the abdominal cavity. The terms "hernia of muscle" and "hernia of the lung" are often applied to a prolapse, not a true hernia.

Structure.—A hernia consists of a *sac*, *covering*, and *contents*. The sac of an abdominal hernia is formed of peritoneum and is divided into a constricted proximal portion (the *ring* or *neck*), an opening into the neck (the *mouth*), and a more distended distal portion (the *fundus* or *body*). The sac may be flask-shaped, hour-glass shaped, multilocular, or irregular. The coverings are formed from overlying layers of the abdominal wall, modified by stretching and com-

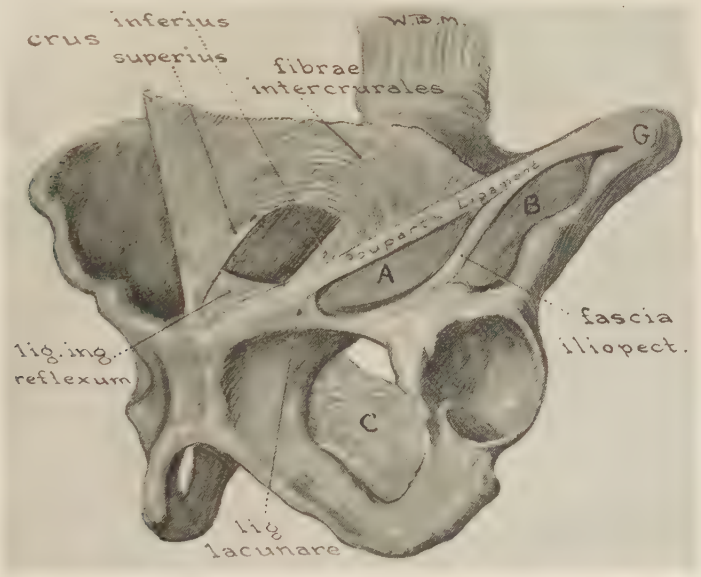


Fig. 921.—The inguinal, femoral, and obturator canals and their boundaries.

pression. The sac may be preformed as in a *congenital hernia*, or of gradual development as in an *acquired hernia*, and is always adherent and irreducible. The sac is subject to inflammatory changes, thickening, adhesions to the contents, loculation or hour-glass contraction, and hydrocele formation. The *coverings* are the structures originally lying over the hernial orifice; the layers (except the skin), subcutaneous fat, and peritoneum usually become fused, thin, and indistinguishable.

The *contents* of the sac usually are small intestine and omentum, less frequently large intestine, bladder, epiploic appendices or the vermiform appendix, rarely the stomach, kidney, pregnant uterus, or other intra-abdominal viscus except the pancreas.

Varieties.—A. As to Time.—(1) *Congenital*, the hernia exists at birth; (2) *acquired*, it develops after birth, although the hernial sac may have been present at birth.

B. As to Location.—(1) *Internal hernia* refers to those occurring within the abdomen with no involvement of the abdominal parietes; (2) *interstitial* or

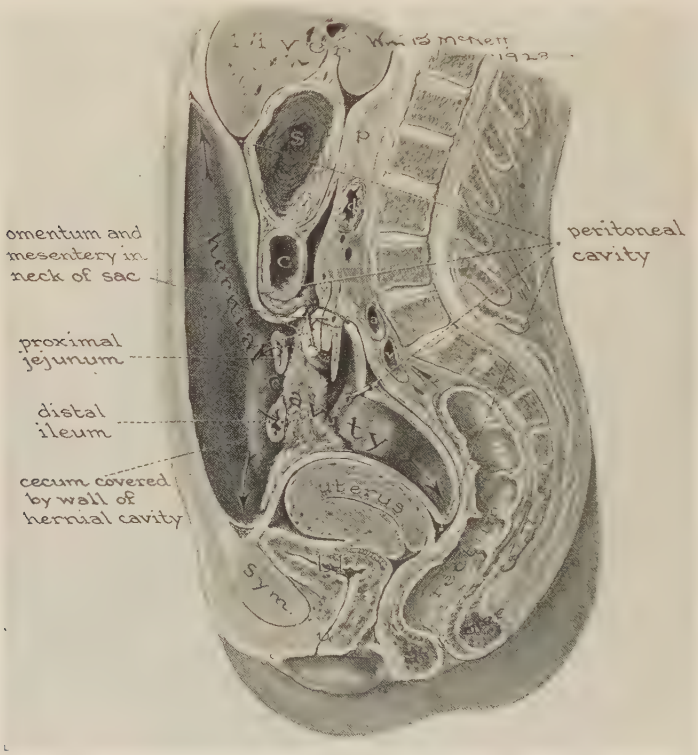


Fig. 922.—Enormous interstitial (umbilical) hernia with wide separation of the layers of the abdominal wall, great encroachment upon the abdominal cavity, which has become so small that reduction of the hernial contents cannot safely be undertaken. For such a large hernia the inner wall of the sac should be split, converting the abdominal cavity and hernial sac into one large sac.

properitoneal, lying between the layers of the abdominal wall; (3) *external hernia* is one that protrudes through the parietes, the sac lying under the skin and subcutaneous fascia. In the *incomplete* form the sac occupies the canal, is not subcutaneous, and does not protrude from the body. In the complete form the sac protrudes from the body, and is at least partially subcutaneous. (4) *Inguinal hernia* involves the inguinal canal; (5) *femoral hernia* traverses the femoral canal; (6) *scrotal hernia* occupies the scrotum; (7) other varieties according to location are *ventral*, *obturator*, *lumbar*, *sciatic*, *vaginal*, and *diaphragmatic hernia*.

C. As to Causation.—(1) *Traumatic*, due to injury, and (2) *incisural* or *postoperative*, following operation.

D. As to Contents.—(1) *Enterocele*, a hernia containing small intestine; (2) *epiplocele*, a hernia containing omentum; (3) *cystocele*, one containing the urinary bladder, the hernia reducing on urination or catheterization; (4) *Richter's hernia*, a sac containing only a part of the circumference of the bowel; (5) *cecocele*, containing the cecum; (6) *Littre's hernia*, a sac containing a blind diverticulum only, such as Meckel's diverticulum or the appendix vermiformis, and (7) *sliding hernia (hernia par glissement)*, containing a portion of the large intestine, usually the sigmoid, without a mesentery, so that the bowel forms a part of the wall of the sac.

E. As to Reducibility.—(1) *Reducible*, contents return to abdomen spontaneously or on manipulation, and (2) *irreducible*, contents cannot be returned to abdomen by external manipulation.

Etiology.—1. *Age:* Hernias are more common during infancy and between fifteen and fifty years of age.

2. *Sex:* Men are involved six times as frequently as women, femoral hernia being relatively more common in women. Umbilical hernias of childhood are divided equally between the sexes, but after middle life they are more often met in women.

3. *Heredity:* There is a history of hernia in the immediate progenitors in 25 per cent. of cases, a weakness predisposing to hernia being transmitted.

4. *Developmental Defects:* Large normal apertures, inguinal, femoral or umbilical, favor the development of hernia. In the inguinal region, an undescended testicle or patent funicular process aid in the development of hernia. Especially predisposing are abnormal congenital apertures along the linea alba, linea semilunaris, or in the diaphragm or deep peritoneal or subperitoneal fossæ. Developmental defects explain the sudden development of hernias.

5. *Acquired Defects:* Weakened abdominal walls caused by: (a) Prolonged illness, emaciation, starvation, operative or traumatic injury, obesity or senility; (b) distention from pregnancy, ascites, and ovarian or other tumors; (c) conditions increasing the intra-abdominal pressure. Violent muscular strain, the wearing of tight belts or corsets, straining from hemorrhoids, phimosis, hypertrophied prostate, urethral stricture, chronic constipation, and persistent cough (as in phthisis), all favor the development of hernia. It is rare that a hernia of sudden development is produced entirely by muscular strain.

Elongation of the mesentery (splanchnoptosis) may facilitate the development of inguinal or femoral hernia.

Traumatic Hernia (Hernia Produced by Accident).—Claims for damages and compensation are often made for hernia said to have been due to accident. A hernia of sudden development indicates the pre-existence of a hernial sac. This is particularly true in hernias of considerable size and within the scrotum. For the most part, a so-called "traumatic inguinal" or "femoral" hernia is an "incomplete" or "small" hernia that has enlarged, and has been brought to the patient's attention by muscular strain. Under stress, old abdominal scars may yield, with the production of hernia or the enlargement of small pre-existing sac. In the City of Philadelphia, damages were awarded a woman who claimed that

a ventral hernia was caused by a violent bimanual vaginal examination. I have seen but one instance of unquestioned traumatic hernia: A powerful colored man, using every effort to push a heavy swinging dynamo that threatened to crush him, suddenly felt a burning sensation through the body, became faint, and collapsed, as a mass the size of a grape-fruit developed along the right semilunar line.

Hernias may be intentionally produced in order to avoid military service or for other purposes. Formerly, in Russia, certain women manually dilated the inguinal canal, to produce hernias in those who desired to escape military duty.

Edema, effusion of blood, swelling and tenderness about the hernia sac immediately following the accident, would suggest a traumatic origin but are rarely found. Enlargement and exacerbation of a pre-existing hernia may justify liability.

Symptoms.—(1) An *opening* through the abdominal parietes, abnormal on account of size or position; (2) *swelling* or mass filling the hernial opening and canal; (3) *expansile impulse* transmitted to the mass on coughing or straining; (4) *tympany* on percussion is present with an enterocele; dulness with an epiplocele; (5) *reducibility*—on lying down or on manipulation the contents slip back with a characteristic slip, flop, or gurgle; to reform from within outward, on standing, coughing, or straining. When the mass is reduced and sufficient pressure is made over the orifice of exit from the abdomen, the mass does not reappear on straining. The hernia may be irreducible from adhesions, size, or shape of contents.

A hernia may exist for years without inconvenience, or without the patient being aware of its existence. The patient may even be unaware of the location of a strangulated hernia. There is usually a sense of local weakness, and the enlargement of a hernia under strain is uncomfortable.

Differential Diagnosis.—1. *Enterocele* is elastic and tympanitic, and may gurgle on manipulation or reduction.

2. *Epiplocele* is doughy, dull, slightly lobulated, irregular, and often irreducible.

3. *Hydrocele* protrudes from the body, has a pyriform shape, is tense and dull on percussion, translucent to light, and the testicle has a median and posterior position. With an open hydrocele, fluid passes into the abdominal cavity on recumbency and, on standing, the sac fills from below upward, instead of from above downward as in the case of hernia. Reduction is not associated with the characteristic slip or gurgle. A hydrocele on the cord is oval, firm, slightly elastic, and may be pushed more deeply into the canal, but cannot be completely reduced and has no expansile impulse. It slips in and out, has distinct limits above and below, and moves from traction on the cord.

4. *Congenital hydrocele* is translucent and gives an impulse on coughing. It disappears on recumbency, but, on standing, refills from the bottom upward despite pressure over the inguinal canal.

5. *Varicocele* or *varix*, a worm-like elastic mass that gives an impulse on coughing and straining. It is reduced by pressure and recumbency, but recurs and is increased in size by pressure over the canal and ring, while the hernial slip and gurgle are absent.

6. *Hematocele* develops subsequent to injury. There is ecchymosis or suggillation of the adjacent subcutaneous tissues, and the mass is doughy, irreducible, dull on percussion, and opaque to transmitted light.

Treatment.—*Manipulative Reduction of Hernia* (*Taxis*): The patient should be recumbent and in a position of relaxation, with the thighs adducted and flexed. The hernial sac should be uniformly compressed. Manipulation is made near the neck of the sac, which is steadied, so that the contents that escaped last are the first returned to the abdomen. The *dangers of taxis* are fatal delay in case of a strangulated hernia, injury to the sac or bowel, tearing of the abdominal wall, and reduction *en bloc* to a properitoneal or intraperitoneal position.

The treatment of hernia may be (a) *mechanical* or *palliative*, or (b) *operative* or *radical*. 1. MECHANICAL TREATMENT consists in the wearing of a truss, belt, or other mechanical device, as a curative or palliative treatment. This is usually curative for the infantile type of umbilical hernia, occasionally so for inguinal hernia of children, but only palliative in all other hernias. As a palliative treatment the mechanical device (a) maintains reduction of a reducible hernia by pressure upon the ring and canal, or (b) supports and limits further enlargement of an irreducible hernia. The results of mechanical treatment are improved in certain cases by exercises tending to develop the muscles and other structures about the point of weakness.

After the age of four, mechanical treatment is palliative and not curative although, after wearing a truss, the patient may be able to discard it for months or even years before the hernia again slips down.

Fig. 923.—Hydrocele is translucent and projects from the body instead of hugging the thigh, as does scrotal hernia, and the contour of the testicle is obscured.

A spring truss consists of a hard-rubber pad which, through an attached spring or band, makes pressure over the internal ring and canal through which the hernia escapes. The pad should not produce pain or press upon the bone, spermatic cord, or important blood-vessels. The spring is made of steel, covered by hard rubber, celluloid, or leather which, for an inguinal or femoral hernia, encircles the body below the iliac crests and makes pressure and counterpressure. A perineal strap is often necessary to prevent upward displacement of the pad. The truss should be worn constantly except when the patient is recumbent, being removed after the patient has gone to bed and reapplied before he arises. In infants it should be worn both night and day. Varieties include the "cross body truss," the "double truss" (as the Hood truss), the "rat-tail truss," and the "bag" or "cup" truss which is worn for irreducible hernia.

Contraindications.—A truss with a pad should not be applied over irreducible omentum or intestine, an inflamed hernia, a hydrocele or undescended testicle, a properitoneal or interstitial hernia, or where ignorance, poverty, or occupation prevent its proper use. A truss should not be worn when it causes pain or ulceration of the skin, or if it fails to retain the hernial contents.

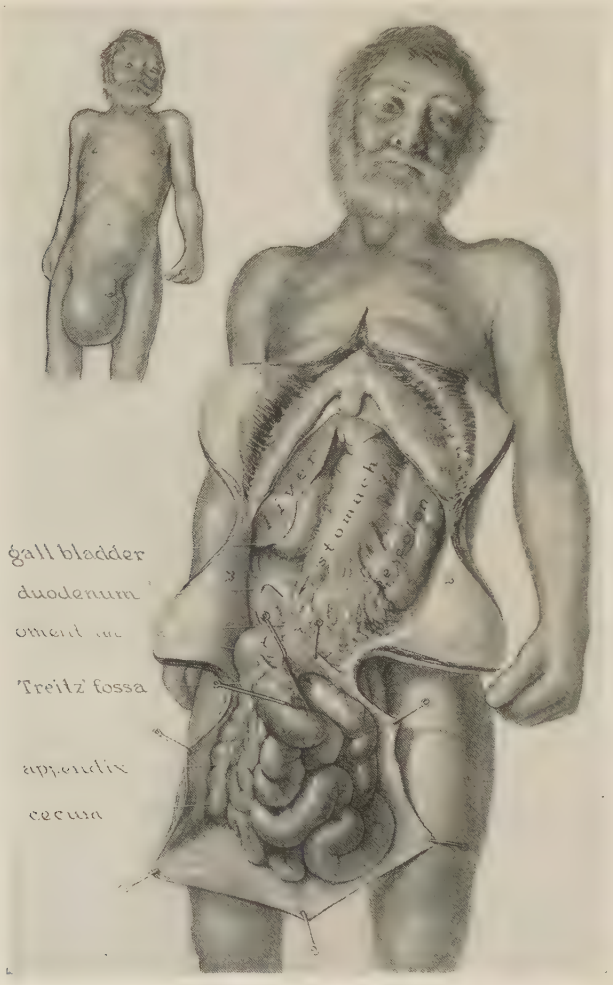


Fig. 924.—Large, irreducible, incarcerated and inflamed sliding right scrotal hernia containing nearly all of the small intestine. Death without operation. Operative reduction of these large hernias in one stage usually is fatal from intra-abdominal tension.

2. Operative or radical treatment is the only curative treatment for most forms of hernia.

Herniotomy is the division of the constricting ring to relieve a strangulated hernia. For this operation the herniotome of Sir Astley Cooper was used by a former generation of surgeons.

Herniorrhaphy (*hernioplasty*) is suture of the parts for the cure of a hernia.

The operation consists of: (1) An incision, exposing and opening of the sac; (2) the reduction of the contents of the hernia; (3) ligation or suture of the neck and removal of the sac; (4) obliteration of the hernial orifice, and (5) closure and reinforcement of the canal by suture of the adjacent fascia and muscle, with restoration of the obliquity of the canal so that the hernial rings are not superimposed. Closure by suture of red muscle is not effective, unless supported by white fascia or aponeurosis.

After operation for hernia the patient should not sit up in bed for from ten to twenty-four days. Cough is prevented by sufficient doses of codein or morphin, given by hypodermic injection or by mouth. Elderly, obese patients with thin weak tissues are kept in bed for the longer time. A firm, well-fitting spica or other type of bandage should be renewed weekly for six weeks from the time of operation, and lifting or strain interdicted for three months. Usually after six weeks no bandage, truss, or support is needed, and after three months laborious work may be resumed.

Pathologic Conditions of Hernia.—These include *irreducibility*, *inflammation*, *incarceration*, and *strangulation* of the hernia. Occasionally the patient

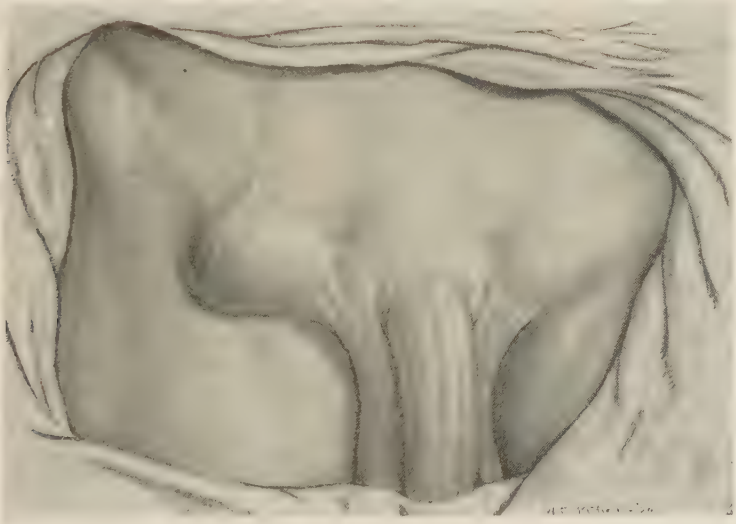


Fig. 925.—Strangulated right femoral hernia in a man. The mass is tense, firm, irreducible, and nearly free from tenderness; the distress is referred to the upper abdomen.

suffers from recurrent diffuse abdominal colic and from interference with peristalsis. The local pain is rarely severe, and sensitiveness in the absence of inflammation is unusual. If untreated or unsupported, the hernia tends to grow progressively larger.

A. **Irreducible hernias** in the order of frequency are *umbilical*, *femoral*, and *scrotal*. The cause of the irreducibility is usually adhesion within the sac, or bulk of contents too great to be returned through the hernial ring. Irreducible hernias chiefly contain fatty omentum. Sliding hernias are always irreducible. Irreducibility prevents the wearing of an efficient truss, and the patent opening or the associated adhesions favor strangulation, incarceration, and inflammation.

Treatment.—Herniorrhaphy is the preferred treatment for irreducibility. If operation is contraindicated or refused, an attempt may be made to render the hernia smaller or reducible by rest in bed with the foot of the bed elevated, a light diet, regulation of the bowels, and local pressure upon the sac by a shot- or sand-bag, the pressure of a frequently adjusted and well-padded spica, other bandage, or a bag-truss. This treatment may succeed in reducing the size of the hernia so that an operation will be safer, or so that a bag- or cup-truss of moderate size may be worn.

In persons of middle age or advanced years, the sudden operative reduction of a hernia larger than a cocoanut is often followed by excessive intra-abdominal tension, intestinal obstruction, and death. The abdominal cavity may become contracted during the months and years that a part of the contents were in the hernial sac and, consequently, the hernial contents have "lost their right of domicile." In such cases the hernia should gradually be reduced in size by pre-

Fig. 926.—Section of a femoral hernial sac showing that the hardness and tension of the lump is due largely to fluid exudate in the sac. a, Femoral artery; v, femoral vein.

operative treatment or multiple stage operations and the patient should also receive attention for any associated myocardial or parenchymatous degeneration.

B. Inflammation of a Hernia.—*Etiology:* Traumatism from a truss, blow, taxis, irritation from adhesions, perforation from a pin or other foreign body, or inflammation and perforation of an appendix, fallopian tube, or intestinal diverticula may involve a hernia. In strangulation there is no inflammation outside the hernial sac in the early stages. With an inflamed hernia there are redness, swelling, heat, pain, involving the subcutaneous tissues and skin overlying the sac, and the sac and its contents may be infected by bacteria that have passed through the intestinal wall. The inflammatory exudate is serous, plastic, or purulent.

Treatment is rest, elevation of the hernial sac, if large, and the application of

evaporating and cooling lotions. If an abscess forms, it should be evacuated, and suppuration or perforation in the sac treated by incision, occlusion, by gauze packing, and drainage. A radical herniorrhaphy should not be attempted while inflammation is present.

C. **Incarceration or Obstruction of a Hernia.**—An irreducible hernia in which the fecal current is blocked by a mass of feces. The obstruction usually occurs in the transverse colon in large umbilical hernias of middle-aged and obese persons. The condition is favored by a relaxed abdomen, a constipated habit, a relaxed atonic colon, and the presence of adhesions within the sac.

Symptoms.—The hernia becomes enlarged, doughy, and at times somewhat painful. The sac is not hard and tense as in a strangulated hernia, and there is constipation, nausea, tormina, and sometimes a little vomiting. The symptoms may last from a few hours to several days, are more gradual in onset, and less severe than the symptoms of strangulation, and are relieved by purgation.

Fig. 927.—Right-sided strangulated femoral hernia. The sac is exposed and is distended by blood-stained liquid.

Treatment should include rest in bed, repeated enemas, rectal examination to make sure that the rectum is empty, a light diet, pressure, an ice-bag over the hernia, and gentle massage or taxis. A herniotomy should be done if the symptoms persist over six hours. Strangulation may occur in a subsequent attack, or at the time of the first attack. Operation is often desirable either during the attack or when it is over.

D. **Strangulated hernia** is characterized by the interruption of both the blood and fecal circulation in a hernia.

Etiology.—(1) Entrance of additional bowel into the sac with constricting pressure; (2) swelling and inflammation of the intestine in the sac; (3) fecal accumulation within the sac, and (4) adhesions within the sac, producing compression, angulation, or obstructive torsion of the contained bowel. The con-

striction usually occurs at the neck of the sac in congenital inguinal hernia, at the internal abdominal ring in acquired inguinal hernia, and at the lacunar (Gimbernat's) ligament in femoral hernia.

Pathology.—The venous return from the bowel is first arrested by the pressure, the contained gut becoming deeply congested, purplish or even black. The arterial circulation is arrested, and there is a white or grayish ischemic groove at the point of constriction, which may become necrotic and perforate, with edema and redness of the adjacent living bowel on the abdominal side. Serum, followed by blood and bacteria, transudes from the bowel into the sac. The sac at first contains bloody fluid, succeeded by dirty, fetid fluid, and pus. The peritoneal coat of a bowel at first is shiny but becomes lusterless and rough, the gut becomes gangrenous, ruptures, and inflammation spreads to the external tissues which, if the patient survives, may give way with the formation of an external fecal fistula. The bacteria usually pass through the ring into the abdomen, producing diffuse peritonitis. The bowel proximal to the hernial obstruction becomes greatly distended.

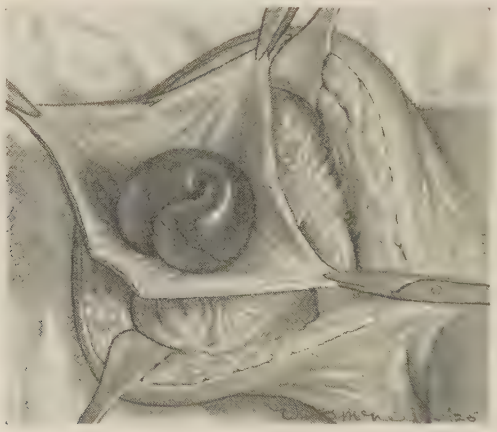


Fig. 928.—Strangulated femoral hernia. The sac has been opened, blood-stained fluid has escaped, the strangulated loop of ileum, although dark red or nearly black, is shiny, resilient, and viable.

Symptoms are those of an acute mechanical ileus, followed later by signs of spreading peritonitis. There is shock, constipation, vomiting, abdominal distention, and, after the lower bowel has been emptied, inability to evacuate gas or fecal material. The vomiting is at first of the contents of the stomach, later bile and the contents of the jejunum and duodenum and, finally, the yellowish or brownish foul fluid from the upper intestines (*fecal* or *stercoraceous vomiting*). In Richter's and Littré's hernia there may be one or more movements of the bowels despite strangulation. Until the onset of peritonitis, the temperature is normal or subnormal. The pulse-rate is not increased at first, but later becomes rapid, the face pale and drawn, and the expression anxious. The tongue becomes dry and brown, there is great thirst, and the urine is scanty and concentrated. With strangulation of the omentum the symptoms are less severe, and the fecal current may not be arrested.

The hernia, usually a small femoral or inguinal one, becomes tense, hard, and at times somewhat painful and tender. Often, however, there is no local pain or tenderness, and the patient may be unaware of the presence of the small

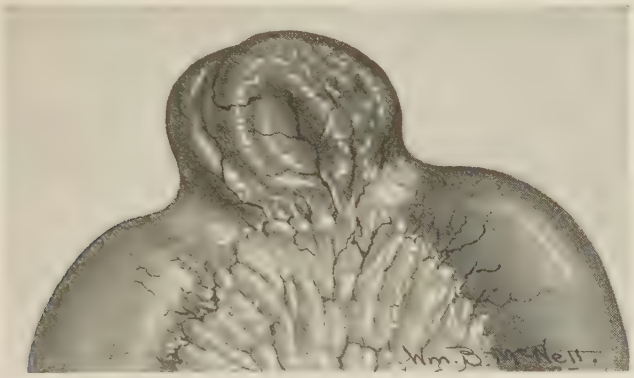


Fig. 929.—Strangulated loop of bowel from hernial sac showing constriction from pressure at the hernial ring, the gut is viable. A strangulated loop should always be pulled well out of the wound to make sure that the constriction at the abdominal ring has not produced necrosis. Bowel reduced with radical herniorrhaphy without drainage.

hernia. Temporary relief from tormina, nausea, vomiting, and pain follows the beginning of gangrene; to be succeeded by the evidences of a rapidly increasing peritonitis, with intestinal regurgitant vomiting. The onset of gangrene de-

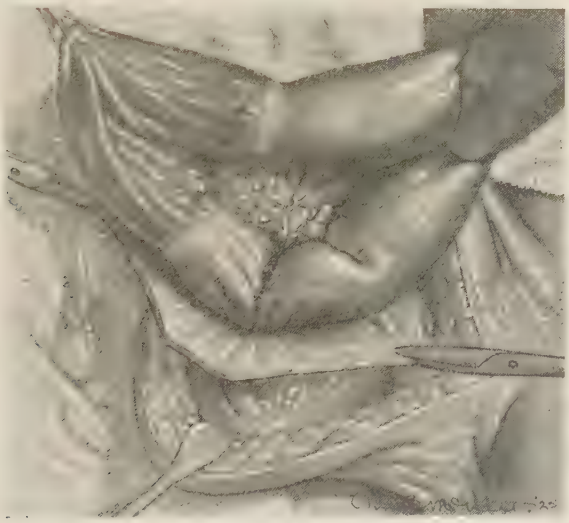


Fig. 930.—A strangulated loop of bowel withdrawn from hernial sac showing grooves from pressure necrosis. Resection of intestine, enterostomy, or the formation of an artificial anus is necessary.

pends upon the completeness of the arrest of circulation. It may develop within two hours or, rarely, be absent after four or five days of strangulation.

Treatment.—The preferred treatment for strangulated hernia is immediate operation, as soon as the patient has reacted from the primary shock; or during

the shock, if it is not intense. If operation is refused, the patient should be placed in bed with the buttocks high, the head low, the thighs flexed and adducted, the hernia supported. The skin over the sac should be sprayed with ether or ethyl chlorid and, if this fails to produce reduction, an ice-bag should be applied over the sac. One-fourth of a grain of morphin, and 1/60 grain of atropin should be given hypodermatically. If the hernia is not spontaneously reduced within two hours, general anesthesia or, preferably, spinal anesthesia should be administered and gentle taxis tried. With the abdomen relaxed, and the thighs flexed and adducted, one hand steadies the neck of the sac and the other compresses the hernia, and works it back along its line of exit. If this is not successful within ten minutes, operation should be performed.

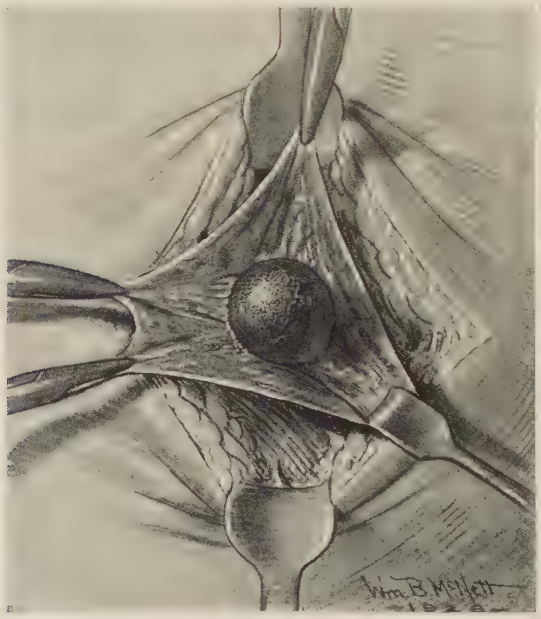


Fig. 931.—A strangulated femoral hernia, with early gangrene of intestine. The sac is injected, inflamed, and somewhat necrotic, the loop of bowel has lost its resiliency and shiny surface, and is malodorous. Resection or enterostomy is necessary.

Strangulated inguinal hernia in infants is most common during the first year. Taxis is dangerous and uncertain and operation is advised. It has a mortality of about $\frac{1}{2}$ per cent.

Herniotomy is best performed under spinal or local anesthesia. With strangulation, the stomach should be emptied by lavage before operation. The sac should be opened, the constriction located and divided either from without inward, under direct vision, or from within outward. In the latter a hernia knife (herniotome), guided by the fingers, is passed through the neck of the sac. In direct and indirect hernia the cut should be up, and in femoral hernia up and medial. The bowel should immediately be withdrawn from the sac, and the zone of constriction examined for possible necrosis, ulceration, or perforation. The *viability of the intestine* is determined by *color*, *consistence*, *circulation*, and *odor*. Often

the bowel is slaty black, but still viable. A shiny peritoneal coat, the improvement of color after the constriction is relieved, the absence of odor, a resilient feel, with continuous oozing when the bowel is scratched, indicate viability. Absence of the shiny peritoneal coat, rough surface, grayish color, offensive odor, failure of the color to improve when the constriction is released or a hot moist pad applied, absence of resiliency or a wet-paper feel to the bowel, and lack of continuous oozing when the surface is scratched indicate that the bowel is dead. When there is a question as to the viability of the gut, it may be anchored in the wound and temporary drainage employed. A catheter or a Paul or Mixter glass-tube may be tied in the gangrenous bowel, which is isolated by gauze. Where two or more loops of bowel are strangulated in the same sac, gangrene may involve a segment of bowel within the sac, *or only the connecting loop within the abdomen.* It is, therefore, very important to examine the adjacent bowel in the abdominal cavity. If the bowel is normal it is returned to the abdomen. Small local areas of gangrene may be enfolded by suture. Larger areas should be resected with end-to-end anastomosis, or surrounded by gauze, anchored in the wound, and a colostomy or a two- or three-stage Mikulicz type of operation performed. Care should be taken to prevent the entrance of septic products into the abdomen. The wound is to be closed in layers with a radical herniorrhaphy or left open and drained, according to the absence or presence of infection in the sac. As in other forms of intestinal obstruction, the free use of salt solution subcutaneously, and at times a high enterostomy may be desirable.

Bacteria pass through living strangulated bowel, and may cause a secondary serious or fatal peritonitis after the herniorrhaphy.

Secondary obstruction, occurring two or three weeks after an operation for strangulated hernia, is due usually to the development of a fibrous stricture at one or both points of previous constriction, or to adhesions with obstruction. The symptoms are tormina, more or less distention, possibly visible peristalsis and regurgitant vomiting.

Treatment is reoperation, with liberation, resection or anastomosis of the involved portion of the bowel, or the formation of a temporary enterostomy or artificial anus.

SPECIAL HERNIAS

Inguinal hernia is a hernia through the inguinal canal, and constitutes 84 per cent. of all hernias. Although the most common hernia in women, it is six times more frequent in men. In men, on account of the descent of the testicle, the inguinal canal is larger, and hernias more often occur on the right side from the later descent of the right testicle.

Varieties.—(1) Indirect inguinal hernia, oblique or lateral inguinal hernia; (2) direct or medial inguinal hernia, and (3) interstitial inguinal hernia.

I. **Indirect, oblique,** or **lateral inguinal hernia** follows the spermatic cord into the scrotum or the round ligament into the labium majus. Leaving the abdomen through the abdominal (internal) inguinal ring, it traverses the inguinal canal and emerges through the subcutaneous (external) inguinal ring. This variety constitutes 93 per cent. of all inguinal hernias.

A. Acquired Varieties Form Gradually.—(a) *Incomplete* or *bubonocele*, where the sac is retained in the inguinal canal; (b) *complete*, where the sac ap-

pears under the skin, usually in the scrotum or labia majora, and (c) *potential inguinal hernia*, a name given to an enlarged inguinal canal, within which the bulging peritoneum may be felt when the patient coughs or strains.

Coverings.—The sac lies in front of the spermatic cord, and is covered from within out by: (1) Peritoneum; (2) extra-peritoneal fascia or fat; (3) the infundibuliform (internal spermatic or transversalis) fascia, derived from the transversalis muscle; (4) the cremasteric fascia and muscle, derived from the internal oblique muscle; (5) the intercrural fibers (external spermatic or intercolumnar fascia) from the external oblique, and (6) the deep and superficial fascia and skin. These various layers become fused and attenuated and, except the two inner and two outer layers, cannot easily be differentiated.

Fig. 932.—The oblique inguinal canal, abdominal and subcutaneous inguinal rings, spermatic cord, testicle, and tunica vaginalis (semidiagrammatic).

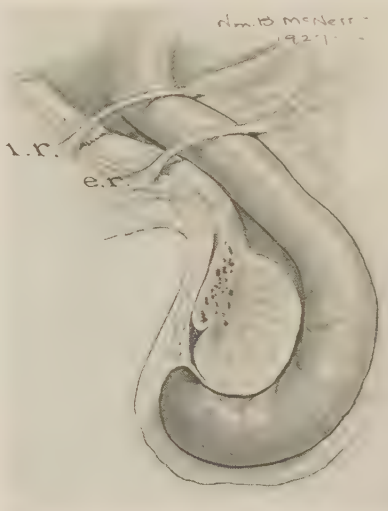


Fig. 933.—Indirect inguinal hernia, congenital type. The hernia occupies the funicular process and tunica vaginalis, and largely surrounds the testicle. *i.r.*, Abdominal inguinal ring; *e.r.*, subcutaneous inguinal ring.

B. Congenital varieties develop suddenly. The sac is formed in the unobliterated vaginal process of the peritoneum. The hernia is present during infancy, but the sac may remain empty until adult life, when the bowel slips down with the immediate evidence of a hernia or strangulation.

(a) *Vaginal*—the sac is formed of the open tunica vaginalis, the hernial contents apparently surrounding the testicle; (b) *funicular*—the hernia occupies the funicular process, which is closed at the subcutaneous ring, but open at the abdominal ring; (c) *infantile hernia* enters a funicular process, open at the abdominal ring but closed below, which becomes invaginated into the tunica vaginalis so that the hernial sac has three layers of peritoneum; and (d) *encysted infantile hernia*, which is an infantile hernia that is invaginated into a hydrocele of the cord or tunica vaginalis.

II. **Direct inguinal hernia** (*hernia through the linea semilunaris*) leaves the abdomen through Hesselbach's triangle, or between the epigastric artery and the

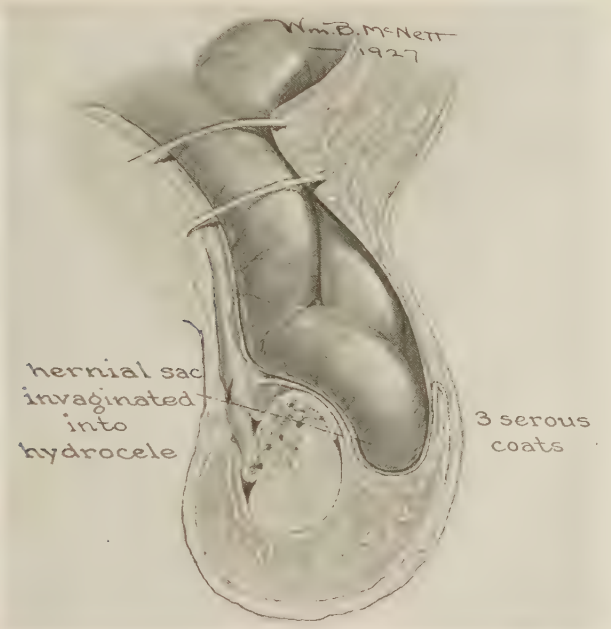


Fig. 934.—Type of infantile hernia, the hernial sac formed by the funicular process has invaginated into a hydrocele giving the lower part of the sac three serous coats.

lateral edge of the rectus muscle. *Lateral direct hernia* leaves the abdomen through the medial inguinal fossa between the inferior epigastric and the ob-

Fig. 935.—Direct inguinal hernia. The sac has no tendency to enter the scrotum.

literated hypogastric arteries; *medial direct*, between the obliterated hypogastric artery and the outer border of the rectus. The coverings resemble those of an indirect hernia, except that in the lateral direct type the transversalis

Fig. 936.—Indirect inguinal scrotal hernia, congenital type. The contour of the testicle is not evident.

Fig. 937.—Bilateral complete indirect inguinal hernia. The sac is beginning to enter the scrotum on the right side.

fascia is substituted for the infundibuliform fascia, the common or medial direct hernia being covered by the transversalis fascia and the falx inguinalis (conjoined tendon), instead of the infundibuliform fascia and the cremasteric fascia. Direct hernias may develop in a congenital diverticulum of peritoneum through the fibers of the falx inguinalis (R. W. Murray).

Etiology.—Adult males, particularly between the ages of forty and fifty. When single, the right side is involved more frequently than the left. Over 50 per cent. are bilateral. The hernia comes directly through the abdominal wall and external ring, lies over or medial to the spine of the pubis, and does not enter the scrotum or labia. The sac is rarely large, is usually easier to reduce and less liable to strangulation than an oblique inguinal hernia, and, when strangulation does occur, it is less serious.

Hernia through the linea semilunaris above the inferior (deep) epigastric artery is rare, and often incomplete so that no external swelling is observed.

Prognosis.—Direct inguinal hernias are more difficult to retain by a truss or to cure by operation, from the lack of obliquity of the canal, the large size of the orifice, and the thinness of the abdominal wall at Hesselbach's triangle.

Diagnosis.—The swelling of an indirect inguinal hernia occupies the groin above Poupart's ligament or, if larger, the scrotum or labium. It escapes from the abdomen mesial and cephalad to the spine of the pubis and Poupart's ligament.

A direct inguinal hernia is suggested by failure of the sac to enter the scrotum or labium by the directness of the opening through the abdominal wall, and the fact that the hernia after reduction is not retained by pressure made over the internal abdominal ring (2 cm. above the middle of Poupart's ligament). With the finger introduced through the hernial canal, the inferior epigastric artery is felt beating to the medial side in an oblique hernia and to the lateral side in a direct inguinal hernia.

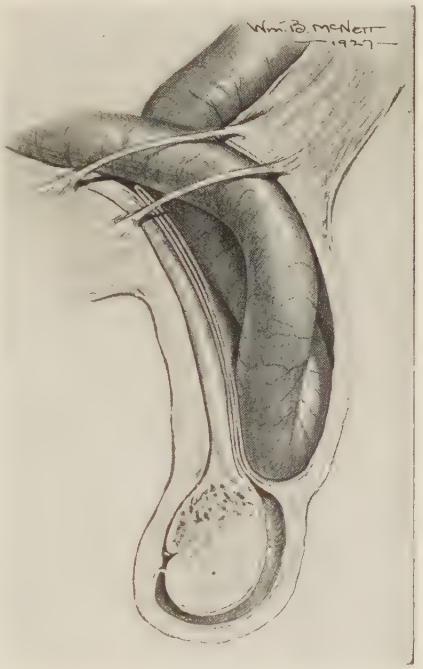


Fig. 938.—Acquired type of indirect inguinal hernia. The funicular process and tunica vaginalis testis are closed, and the testicle is not surrounded by the hernia.

III. **Interstitial inguinal hernia** involves only a part of the inguinal canal. Leaving the inguinal canal, it insinuates itself between the layers of the abdominal muscles; or there may be a congenital indirect inguinal hernia, with a lateral diverticulum that lies between the layers of the abdominal wall.

VARIETIES.—(1) *Properitoneal*, in which the sac lies between the peritoneum and the transversalis fascia, and may extend into the iliac fossa or in front of the bladder; (2) *interparietal*, in which the sac lies between any of the abdominal

muscles; (3) *extraparietal* or usual type with inguinal hernia, in which the sac lies between the external oblique and the skin.

Interstitial hernia is usually associated with an undescended testicle, is often difficult to reduce by taxis, and is liable to strangulation. An external inguinal hernia may be converted into an interstitial hernia by violent efforts at taxis.

Sliding Hernia.—This occurs when a portion of the colon without mesentery enters and forms a part of the wall of a hernial sac, the peritoneum only partially covering the colon. Obviously, reduction is impossible. This type is characterized by a very broad base, the inguinal canal usually being much widened, and a scrotal hernia of considerable size. *Sliding hernia of the sigmoid*, the usual type, is to be suspected when a large left scrotal hernia has a very wide base and

Fig. 939.—Indirect inguinal hernia, acquired type. The testicle is distinct from the scrotal sac.

neck above Poupart's ligament. The cecum may pass into a hernial sac without any peritoneal covering, forming the so-called *sacless cecal hernia.*

In operating, the folds of the peritoneum are divided and reflected from the sides of the colon, and the attached wall of the bowel separated without injury to its blood-supply, and pushed back into the abdomen.

Hernia of urinary bladder (*cystocele*) is found in children and adults, but is rather rare, usually occurring in connection with an inguinal hernia. It may be: (1) *Extraperitoneal*, in which the bladder lies along the side of the hernial sac; (2) *intraperitoneal*, with the protruding portion of the bladder entirely covered by peritoneum and lying within the hernial sac; or (3) *paraperitoneal*, with the medial wall of the hernial sac covered; the bladder projects into, but does not form one of the contents of the sac. This is the most common form. The con-

dition is important on account of the danger of opening the bladder in operating for inguinal hernia. A portion of the bladder may project into a hernial sac, the sac being larger when the bladder is filled, and urination may be aided by compressing the sac with the hand.

Diagnosis may be confirmed by noting the influence of distending and emptying the bladder through a catheter, or by a Roentgen picture after filling the bladder with a solution of sodium iodid or other opaque, non-irritating liquid.

In operating for an inguinal hernia, the proximity of the bladder should be suspected: (1) On noting what is apparently a second thick-walled medial sac; (2) in the presence of extensive, rather dense layers of extraperitoneal fat which usually covers the bladder; or (3) on the exposure of the trabeculated interlacing muscles of the wall of the bladder.

Hernial protrusion of the bladder into the vagina (cystocele) is very common in women with perineal relaxation or laceration. A rectal cystocele is rarely present.

Fig. 940.—Cross-section showing complete enterocele. A loop of intestine has passed through the abdominal and cutaneous rings.

Diagnosis.—A. Of Reducible Swellings: 1. *Femoral hernia* usually occurs in women, the orifice lying below Poupart's ligament, to the lateral side of the pubic spine. The hernia does not enter the scrotum or labium, and is usually of small size, and is not retained by pressure over the inguinal canal.

2. *Congenital hydrocele* transmits light, reduces without a gurgle, and the inguinal canal is empty. It fills from the bottom of the scrotum despite slight pressure over the inguinal canal, reduces without a slip or gurgle, and is usually associated with an indirect inguinal hernia.

3. *Varicocele* feels like a bag of worms, is associated with an empty or closed inguinal canal, and reappears from below upward, despite pressure upon the inguinal canal.

4. *Psoas abscess* is dull on percussion, and may fluctuate, unless gas-producing bacteria are present. It usually lies lateral to the femoral vessels, and is associated with a distention of the iliopsoas above Poupart's ligament, and the signs of vertebral caries and pus formation (*hectic fever*).

5. *Undescended testicle* lying in the canal is associated with an empty scrotum. The upper limits of the mass may be felt, and pressure produces the characteristic testicular sensation, while the impulse is pushing and not expansile.

6. *Saphenous varix* forms a soft elastic swelling over the fossa ovalis

(saphenous opening), which disappears on pressure, but returns despite pressure over the inguinal or femoral canal.

B. Of Irreducible Swellings.—1. *Enlarged inguinal glands* are multiple or fused and irregular, without expansile impulse, and are associated with an empty or closed inguinal canal. A source of infection may be found on the legs, genitalia, or buttocks.

2. *Encysted hydrocele of the cord* forms a tense sausage-shaped mass lying in the inguinal canal, usually in children. It is attached to the cord, traction on which moves the mass, and the upper limits may be felt. Encysted hydrocele

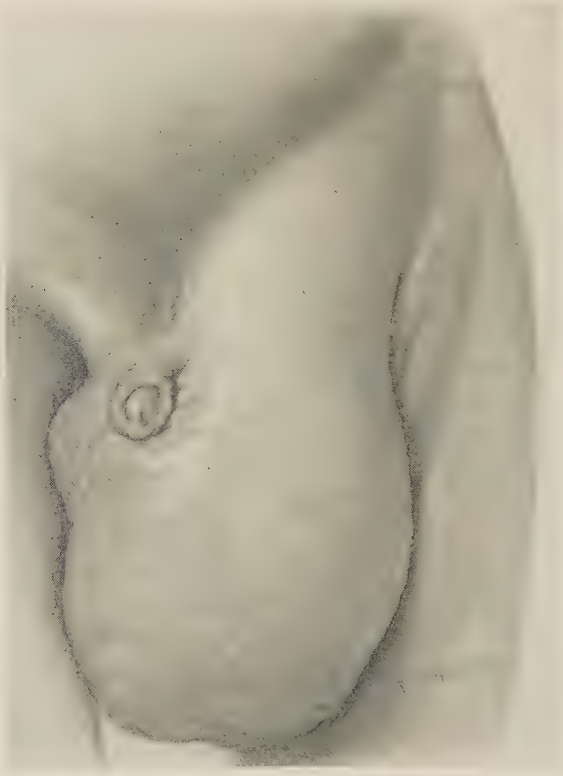


Fig. 941.—Large left scrotal hernia showing the displacement of skin from external genitals to cover the sac.

of the round ligament may be present in the female, or a lipoma or hematocele may occupy the inguinal canal.

3. *Hydrocele of the tunica vaginalis* projects from the body, instead of lying close to the thigh as does a scrotal hernia. It transmits light, the upper border may be felt, and the inguinal canal may be closed or empty. Hematocele is opaque.

4. *Testicular growths* are localized to the scrotum, as are scrotal abscesses, and do not involve the inguinal canal.

5. *Preacetabular bursitis* forms a tense, deep, rounded swelling lying over the hip-joint, the inguinal canal being empty or closed.

Except for the rare condition of an abscess containing air, all swellings of the inguinal region not due to hernia are dull on percussion.

Treatment.—1. Palliative (by Truss Pressure): This is curative in 60 per cent. of infants and children under three years of age. The truss should be worn constantly, pressure being made over the inguinal canal during the time the truss is off or being changed. In infants, a "skein-yarn" truss is simple and sometimes effective.

Irreducible scrotal hernias, the size of a cocoanut or larger, should be treated by a bag-truss or reduced in size before an operation is attempted.

Fig. 942.—Large left inguinal hernia (*continued*), showing the effect of reduction and the application of a truss.

2. Radical operation (*herniorrhaphy, hernioplasty*) is the treatment of choice, and has a mortality of $\frac{1}{5}$ per cent. or less; with recurrence in less than 1 per cent. of indirect hernias, and about 5 per cent. of direct hernias. Recurrences are inversely proportionate to the skill and technic of the operator, or are the result of wound infection, cough, or other strain, during the first three weeks after operation. An operation for an uncomplicated hernia should be avoided while there is acute respiratory infection, or a chronic cough from pulmonary tuberculosis, bronchitis, or asthma. The operation should be carefully considered before it is advised in the presence of severe cardiorenal disease, cirrhosis of the liver, ascites, or diabetes.

Bassini's Operation.—(a) Incision 2 cm. above and parallel with the inner half of Poupart's ligament, the skin being divided for a distance of about 10 cm.; (b) splitting of the fibers of the external oblique, from the external ring to a point slightly above the internal ring; (c) liberation and *opening of the sac*, with reduction of the contents; (d) removal of the sac flush with the peritoneum, after transfixation and ligation of the neck; (e) suture of the internal oblique and transversalis muscles to the shelving portion of the inguinal (Poupart's) ligament, underneath the spermatic cord which is elevated and retracted; (f) suture of the divided aponeurosis of the external oblique over the cord; (g) suture of the subcutaneous fascia and skin.

Babcock's Operation.—(a) A transverse 10-cm. incision is made following the line of skin-cleavage, centering over the abdominal ring; (b) the aponeurosis of the external oblique is split between fibers from the external ring to a point well above the abdominal ring; (c) the sac is located close to the ligamentum inguinale, without disturbing the cord. If the sac is not easily found, the peritoneum is opened medial to the abdominal ring, and the sac located by the finger introduced through

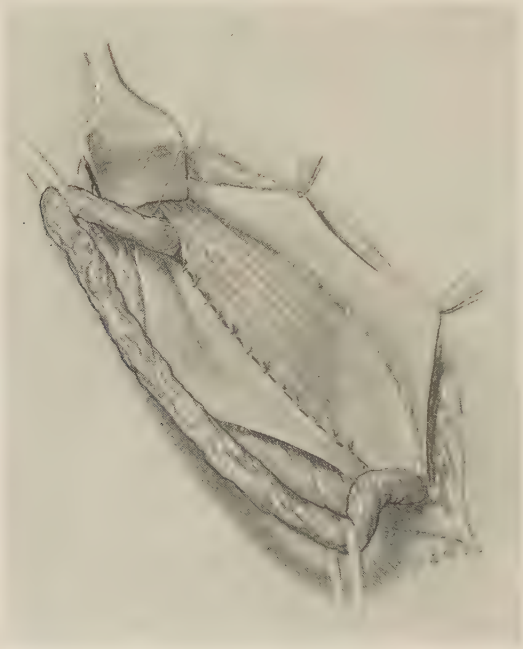


Fig. 943.—The Bassini operation: The internal oblique and transversalis muscles are united to the shelving portion of the inguinal ligament under the spermatic cord. The cord is then placed on this new bed and the aponeurosis of the external oblique muscle united over it.

the abdominal incision. The internal oblique and transversalis muscles are retracted; (d) the sac is opened, the contents examined and liberated, bleeding points ligated, and the contents returned to the abdomen; (e) the sac is separated from the cord by knife and dry gauze dissection, the sac being removed, or, if very large and scrotal, disconnected at the neck of the sac and retained; (f) the neck of the sac is transfixed, and ligated by a long thread of No. 1 or 2 chromic catgut, the ends of the ligature threaded into curved needles, being brought from within out through the edge of the rectus muscle and the inner layer of its anterior sheath; (g) Hesselbach's triangle is reinforced by uniting the edge of the rectus in front of the cord to the thick tough aponeurosis on the posterior edge of the pubis and pubic ramus, by two or three interrupted sutures of chromic gut; (h) the edge of the rectus sheath is approximated to shelving the portion of the inguinal ligament, and the neck of the sac transplanted to a higher level behind the rectus muscle, by suturing the catgut ends from step "f" to corresponding portions of the shelving portion of the inguinal ligament, and tying. The ends of the catgut are now used for a continuous suture, which unites the internal oblique, trans-

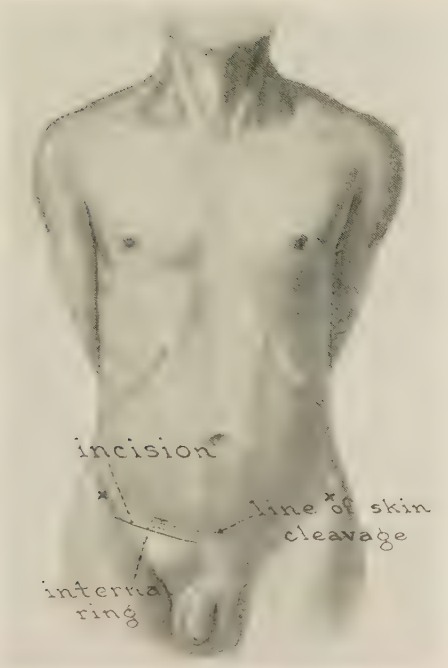


Fig. 944.—Babcock's hernioplasty: A nearly transverse incision, 10 to 14 cm. long, is made, centering over the abdominal inguinal ring. This involves a portion of the abdominal wall easily sterilized and gives a linear, almost invisible, scar.

Fig. 945.—Division of superficial (fascia of Camper) and deep fascia (fascia of Scarpa), showing enlarged subcutaneous inguinal ring, bulging anterior wall of inguinal canal, and darker triangular area, marking the thinner portion of the aponeurosis of the external oblique where the fibers have separated over the canal.

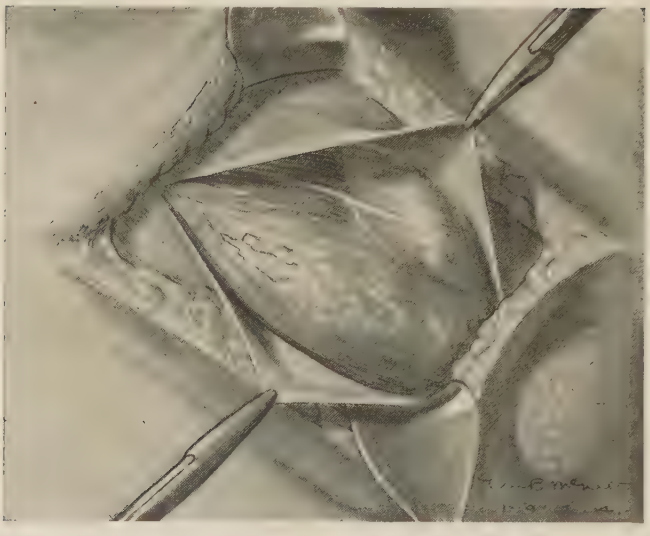


Fig. 946.—Babcock's hernioplasty: Separation of the fibers of the external oblique aponeurosis directly over the canal from the subcutaneous inguinal ring, upward and outward, exposing the internal oblique muscle, the cremaster muscle, the hernial sac, and spermatic cord.

Fig. 947.—Hernial sac exposed and raised on the finger, showing attached underlying vas deferens. The vas is not transplanted, not disturbed, and often is not seen.

versalis, and lateral margin of the rectus to the shelving portion of the inguinal ligament; (i) the edge of the inguinal ligament is brought over the suture lines of steps "g" and "h," and sutured by a continuation of the same thread over the inner layer of the anterior sheath of the rectus muscle,

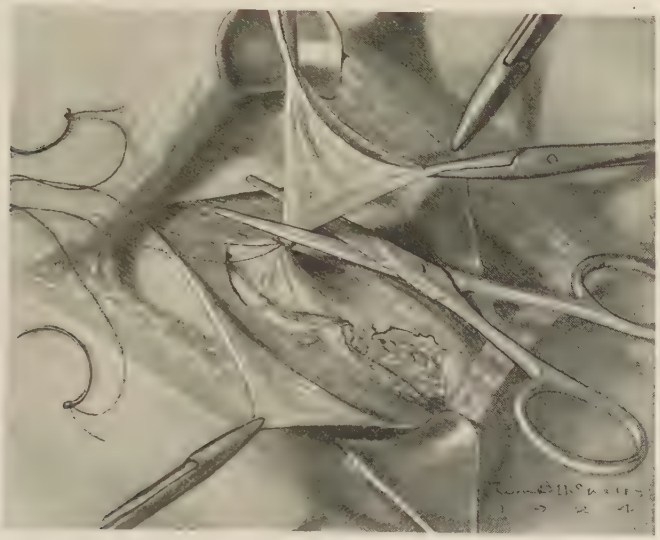


Fig. 948.—The hernial sac has been opened, liberated to the abdominal ring, the contents reduced, the neck transfixed and ligated by a double-ended armed ligature, the ends of which will be used for transplanting the neck of the sac and for closing the inguinal canal.

Fig. 949.—Transplantation of neck of sac and transplantation of rectus muscle. The ends of the ligature from the neck of the hernial sac have been brought through the edge of the rectus muscle and the inner layer of its overlying sheath and have then been passed from within out through the shelving edge of the inguinal ligament, so that, when tied, the neck of the hernial sac will be transplanted behind the edge of the rectus, and the edge of the rectus in its sheath approximated to the shelving portion of the inguinal ligament. For strength in the closure the sheath of the rectus is not opened.

which has been carefully separated well to the midline; (j) the aponeurosis of the external oblique is brought down over all suture lines, and united below the inguinal ligament to the femoral fascia. In the inner angle, if the weakness is marked, a separate suture is used to fasten the external ob-

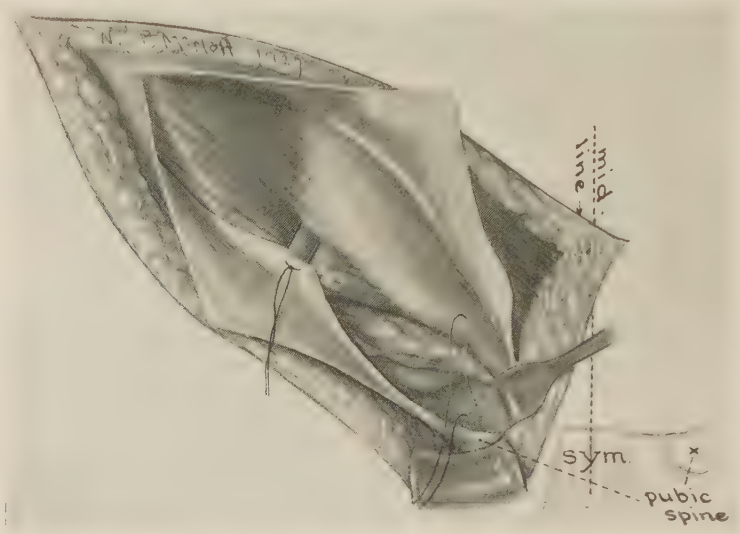


Fig. 950.—Obliteration of Hesselbach's triangle: The inner layer of the anterior sheath of the rectus muscle, in its lower portion, is being sutured to the thick tough ligamentous covering of the posterior superior edge of the pubis, posterior to the pubic tubercle (spine) and to the inguinal ligament. The shelving portion of the inguinal ligament with the attached mattress-suture that has served to transplant the neck of the hernial sac is shown.

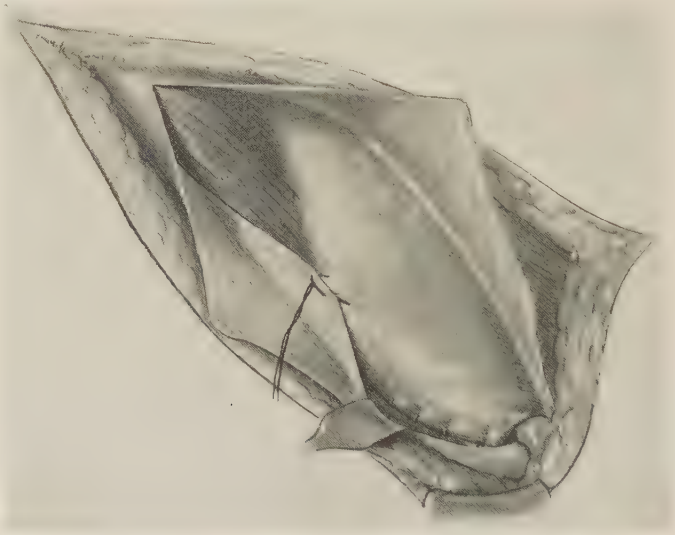


Fig. 951. -Obliteration of Hesselbach's triangle: The area of the conjoined tendon has been obliterated by suturing the lateral edge of the lower part of the rectus within its sheath to the strong fibrous covering over the pubic portion of the ileopectineal line in front of the spermatic cord. In its mesial portion the suture line lies posterior to the tubercle of the pubis, to the triangular fascia (ligament of Colles or ligamentum inguinale reflexum). Laterally the suture line is posterior to the lacunar (Gimbernat's) ligament.

lique to the sheath of the pectineus muscle. Additional reinforcing sutures of fine chromic catgut are inserted in the deep fascia, and the superficial fascia and skin closed.

This operation does not disturb the cord, and rarely is followed by complications within the scrotum.

Postoperative Treatment.—A thick pad is strapped over the wound and supported by a firm spica bandage, which should not compress the abdomen above the level of the iliac crests. The spica is renewed once each week, or whenever it becomes loosened. The patient is kept flat in bed for from ten days for children and young robust adults, to eighteen days for middle-aged or senile patients, or those with much fat or with poor muscular and aponeurotic development. If the wound becomes indurated or inflamed, yellow oxid-of-mercury ointment is applied and the patient is kept in bed until the induration has subsided.

As a rule, the patient leaves the hospital in from fourteen to twenty-one days after the operation, with instructions to report weekly, or whenever the spica becomes loose, for rebandaging, to

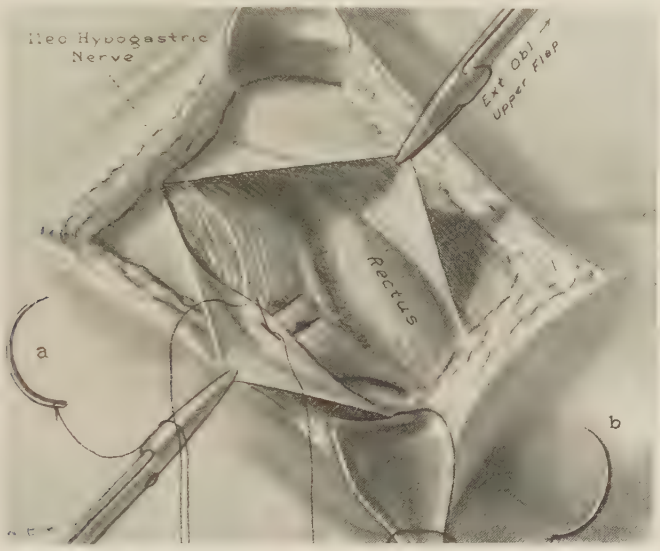


Fig. 952.—Suturing of internal oblique and transversalis muscle to shelving portion of the inguinal ligament. The suture ends from the ligation and transplantation of the neck of the sac, having been carried through the shelving portion of the inguinal ligament from within out, are tied. One suture, *a*, is continued laterally and upward, uniting the internal oblique and transversalis to the shelving portion of the inguinal ligament. Care must be exercised in order not to injure or compress the iliohypogastric nerve. Suture *b* is continued medially and downward, uniting the inner layer of the anterior sheath of the rectus to the inguinal ligament.

avoid active work for six weeks, and lifting for three months. At the end of six weeks all bandages are removed; at the end of three months the patient is permitted to do full work.

Recurrence, not due to defect in technic or in the wound healing, usually results from the separation of the lines of suture during the first two weeks after the operation, caused by severe cough, violent vomiting, persistent hiccough, or by the patient sitting up, or getting out of bed. Every effort should be made to protect the suture line from stress during the early period of healing, especially should cough be prevented. Recurrences, even from direct inguinal hernia, should be very rare. All inguinal hernias that may safely be reduced are curable by operation.

A. H. Ferguson's operation aims to correct the deficient origin of internal oblique and transversalis to the inguinal ligament. It consists of: (a) Semicircular incision convexly upward; (b) free opening of the canal, ligation and division of neck of sac, as described above; (c) reduction of the size of the internal ring by suture, and (d) suture of the internal oblique and transversalis to inner aspect of the inguinal ligament for at least two-thirds of the distance.

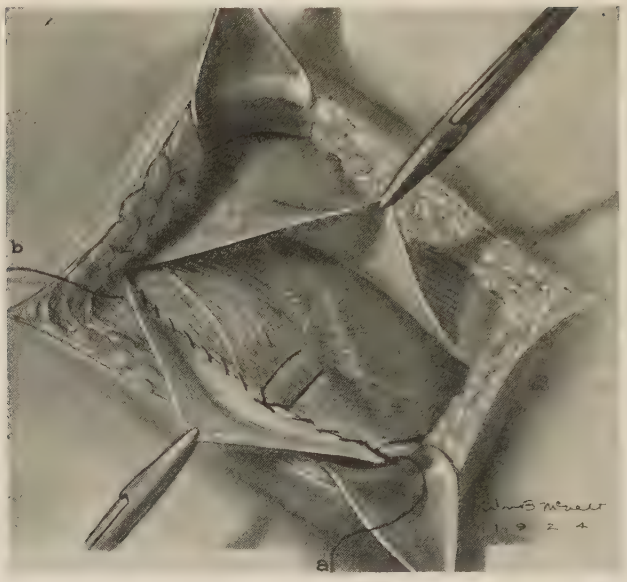


Fig. 953.—Suture of the internal oblique and transversalis muscles to the shelving portion of the inguinal ligament by a continuous suture, the ends of the suture being brought through upon the anterior face of the inguinal ligament as shown at *a* and *b*. In this case, to prevent undesirable tension, the edge of the rectus has not been closely apposed to the inguinal ligament. Usually the inner half of the inguinal ligament can be apposed and sutured to the edge of the rectus sheath. With a strong inguinal aponeurotic falx (conjoined tendon) the closure of Hesselbach's triangle by suturing the sheath of the rectus to the pubis is unnecessary.

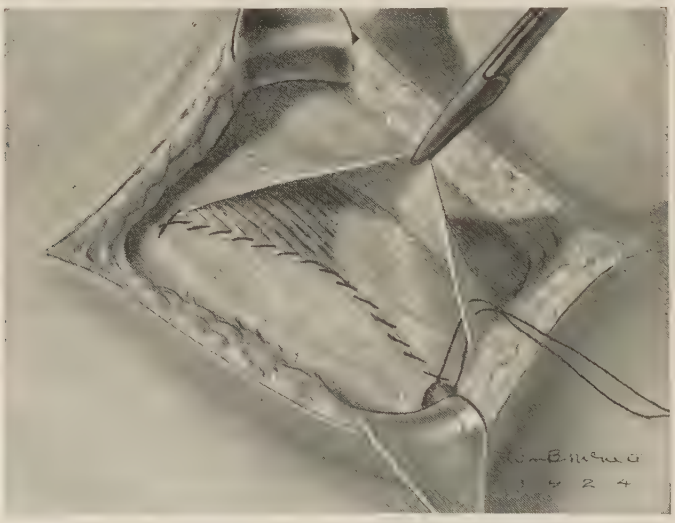


Fig. 954.—Imbrication of the inguinal ligament by a continuation of one of the sutures, the lower flap of the external oblique aponeurosis, including the inguinal ligament, covers the previous suture line and is attached to the internal oblique laterally and to the inner layer of the anterior sheath of the rectus mesially. The ends of the suture are now brought through the upper flap of the external oblique at its medial angle and tied. Hesselbach's triangle has now been reinforced by three superimposed lines of suture with imbrication, uniting strong aponeurotic structures.

Andrews transplants the cord between the layers of the overlapped aponeurosis of the external oblique.

Femoral hernia occurs through the femoral canal and fossa ovalis. It is the second most common hernia, forming 10 per cent. of all hernias, 6.6 per

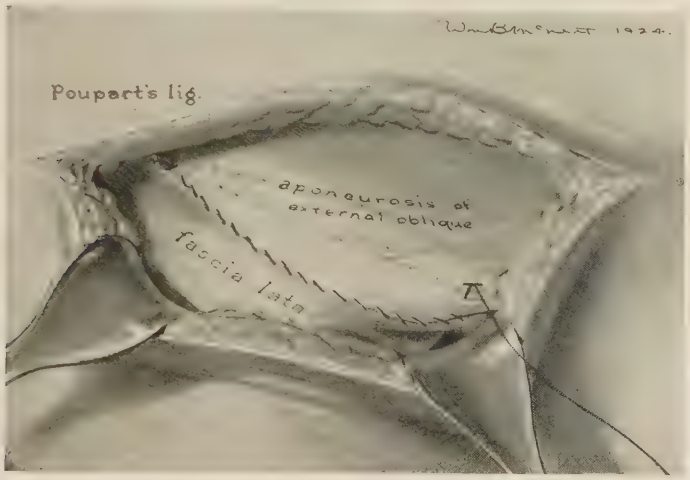


Fig. 955.—Closure of the aponeurosis of the external oblique muscle. The upper edge of the opening through the aponeurosis of the external oblique has been brought down, lapped over the inguinal ligament, and the edge sutured to the fascia lata by a continuation of one of the continuous sutures previously used. The neck of the hernial sac has now been transplanted and the inguinal canal narrowed and reinforced by four strong layers of tissue with imbrication.

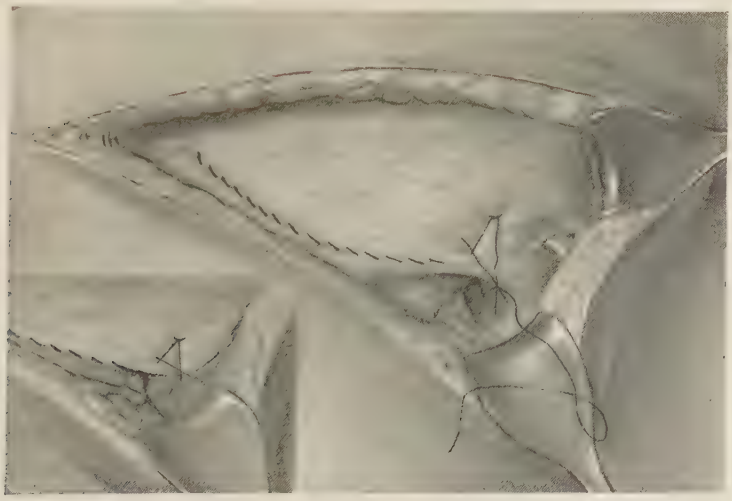


Fig. 956.—Narrowing the subcutaneous inguinal ring. If the subcutaneous inguinal ring is large or more than a narrow slit, it is reduced in size and reinforced by sewing the edge of the external oblique at the medial angle to the sheath of the pectineus muscle. As a rule, this is not required. If the spermatic cord has not been transplanted, the projecting tubercle of the pubis will prevent compression of the associated vessels. Transplantation of the cord is undesirable and should not be used with this technic.

cent. of the hernias of the female, and 3.7 per cent. of the hernias of the male. It is more common in women on account of the wider pelvis and the broader femoral canal, but is less frequent in women than inguinal hernia. Before puberty both sexes are equally but rarely affected.

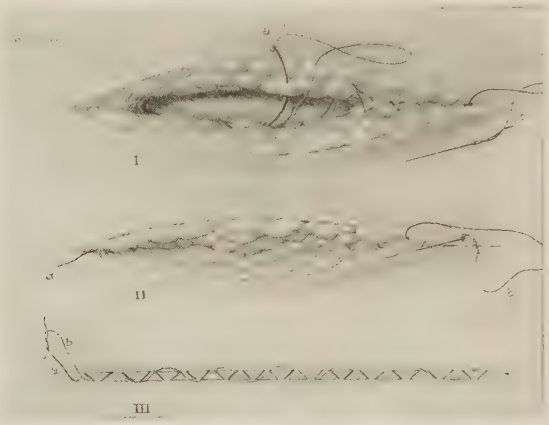


Fig. 957.—Closure of the superficial and deep fascia by a continuous deep and intracuticular suture of No. 00 plain catgut, all knots being buried.

Anatomy.—The femoral canal, the innermost compartment of the femoral sheath, is 12 mm. ($\frac{1}{2}$ inch) long and runs from the femoral ring to the fossa ovalis. It is closed above by the crural septum (*properitoneal fascia*), and below by the cribriform fascia derived from the fascia lata. The femoral sheath

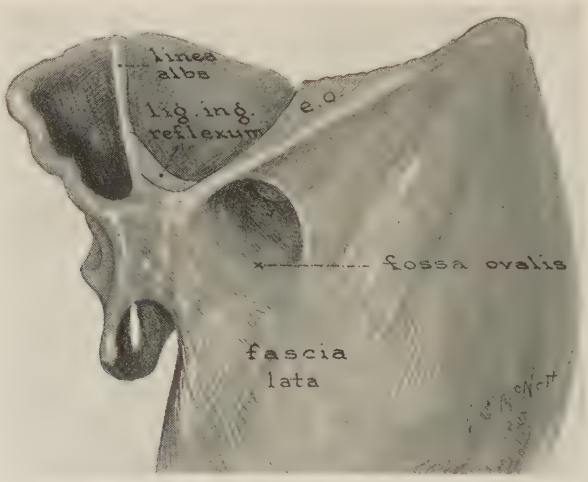


Fig. 958.—Anatomy of the fossa ovalis.

is formed by the junction of the fascia transversalis in front of the vessels and the fascia iliaca behind the vessels.

The sac is always acquired, the neck is situated at the crural ring. Anteriorly is found the inguinal ligament; posteriorly, the pectineal fascia, muscle, and pubic bone; medially, the lacunar (Gimbernat's) ligament; and laterally, the femoral vein.

After emerging from the saphenous opening the hernia tends to ride upward over the inguinal ligament.

Fig. 959.—Indirect inguinal hernia in a woman: The sac lies mesial and superior to the tubercle of the pubis.

The *coverings* from within out are: (1) The peritoneum; (2) the septum femorale (crurale), properitoneal tissue and subserous tissue; (3) the femoral sheath from the transversalis fascia; (4) cribriform fascia from the fascia lata, and (5) deep and superficial fascia and skin.

Fig. 960.—Large femoral hernia in a woman.

Strangulation is usually produced by the edge of the lacunar (Gimbernat's) ligament. The femoral opening is partially covered by the pectineus, and lies medial and inferior to the epigastric vessels, usually superior to the obturator artery. The obturator artery, however, arises from the inferior epigastric in about 35 per cent.

of the cases, and then passes to the medial side of the femoral ring in about 10 per cent., so that it may be injured in about 3.5 per cent. of the cases of femoral herniotomy.

Signs.—Femoral hernia is acquired and of gradual development. The swelling is usually small, rounded or globular, the neck lying inferior and lateral to the pubic spine and the inguinal (Poupart's) ligament. The hernia first descends vertically in the canal and, after emerging from the medial division of the fossa ovalis (saphenous opening), tends to pass up over the inguinal ligament mesial to the femoral vessels and lateral to the tubercle of the

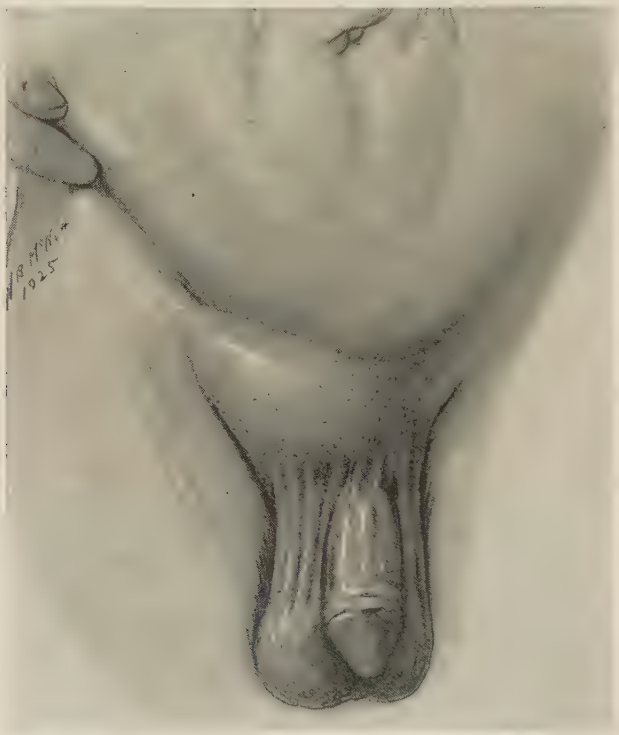


Fig. 961.—Femoral hernia in a man, extending over the tubercle of the pubis. The sac emerges inferior and lateral to the inguinal (Poupart's) ligament and does not enter the scrotum.

pubis. Rarely, it forms a cavity in the substance of the pectineus muscle (*pectineal hernia of Cloquet*) or, very rarely, it descends lateral to the femoral vessels.

Diagnosis.—Femoral hernias are usually small, 2 to 4 cm. in diameter, develop gradually and painlessly, and, when covered by fat, may remain unnoticed for years. They may be overlooked when strangulated, due to the fact that the patient refers the pain to the epigastrium and umbilical region. The neck lies lateral to the tubercle of the pubis, which is located by abducting the thigh and making tense the adductor longus tendon.

Saphenous varix forms a soft swelling, reducible on pressure or recumbency and giving an impulse on coughing, in the region of the femoral (saphenous)

opening. After reduction, however, it is not retained, but is made larger by pressure over the femoral canal, and varicosities lower down on the thigh or leg may be associated, to which a percussion impulse is transmitted. Reduction is not associated with the characteristic slip or gurgle noted with a hernia. Moreover, the femoral canal will be found empty or closed.

Psoas abscess usually appears in the thigh, lateral to the femoral vessels, forming first an enlargement underneath the iliopsoas muscle.

Subperitoneal lipoma, aneurysm of the femoral artery, and enlargement of the inguinal lymph-nodes present obvious points of differentiation from femoral hernia. The lipoma is lobulated, without impulse, dull on percussion, and ir-

Fig. 962.—Saphenous varix suggesting femoral hernia. The mass disappears on pressure or recumbency, but recurs despite pressure over the femoral canal.

reducible. With enlarged lymph-nodes the lumbo-inguinal (crural) branch of the genitofemoral (genitocrural) nerve may be stretched, producing reflex vomiting and constipation, suggesting strangulation of a hernia. A femoral hernia and glandular enlargement, however, may coexist and, in case of doubt, an exploratory incision should be made.

Enlarged *preacetabular bursa* forms a deep, fixed, globular mass beneath the femoral vessels.

Cysts of the femoral canal are rare, irreducible, and without impulse. They may be difficult to diagnose from an irreducible hernia without exploratory incision.

Treatment.—1. PALLIATIVE: The wearing of a truss is not curative, is less

satisfactory in retaining a femoral than an inguinal hernia, and often causes distress from pressure on the pubic bone or the femoral vessels.

2. Operative treatment is simple, safe, and satisfactory, recurrences being rare even after simple reduction and high ligation of the neck of the sac.

Operation includes the following steps: (1) A 4 to 8 cm. nearly transverse incision following the line of skin cleavage, and centering over the lateral edge of the femoral opening. (2) The sac is isolated, opened, and the contents reduced. (3) High ligation of the neck of the sac and transfixation with No. 1 or 2 chromic catgut. (4) Curved needles, attached to the ligatures, are carried through the femoral canal, and brought out through the external oblique just above the inguinal ligament. The ligatures are pulled taut and tied, transplanting the neck of the sac to a point above and behind the inguinal ligament. (5) The lateral or falciform border is sutured to the adjacent pectineus by a few interrupted sutures, and the skin and fascia closed.

Moschowitz Operation [1907] (*Dujarier* [1912], *Seelig and Tuholske* [1914]).—The sac is removed and the opening closed through the inguinal canal, or abdomen (*LaRoque*, 1919). The external oblique muscle is split as for an inguinal hernia, the fibers of the internal oblique and transversalis split or retracted from the inguinal ligament, the peritoneum retracted or opened above the sac, the femoral sac located and grasped from within by forceps, inverted into the wound and excised, and the neck closed and the shelving portion of the inguinal ligament sutured to the pubic ramus, the inguinal canal being finally closed as in an inguinal herniorrhaphy.

Taxis.—The shoulders are raised, and the thighs flexed, adducted, and rotated inward. The hernia should be lifted and drawn down before making pressure. Violent or prolonged manipulation should be avoided, as there is danger of rapid necrosis of the bowel from pressure by the sharp edge of the lacunar (Gimbernat's) ligament. In all cases of ileus the ileofemoral region should be carefully investigated, and operation immediately performed if a tense, irreducible mass (the size of a marble or larger) is found at the fossa ovalis.

Umbilical Hernia.—Hernia through the umbilical ring constitutes 5 per cent. of all hernias, and is most frequent in infancy and in obese persons after middle life. There are three varieties: (1) Congenital hernia of the umbilical cord; (2) infantile umbilical hernia, and (3) acquired umbilical hernia of adults.

1. *Congenital.*—Defective closure of the anterior abdominal wall, with protrusion of viscera (*omphalocele*) forming a large mass, is usually fatal. If of moderate size, the liver usually lies against the opening and is covered by Wharton's jelly. Eventration is present with the larger defects. With necrosis of the umbilical cord, the liver and peritoneum are exposed, and covered by a greenish or blackish gangrenous layer. To prevent a fatal peritonitis, operation should be done immediately after birth, the tissues of the umbilical cord being dissected away, and the defect covered, if necessary, by sliding tissue from the adjacent abdominal wall, or from the lower chest by large double pedicled skin-flaps. Where the defect is less marked, the hernia may protrude into the base of the cord, which is cone-shaped. The gut or other contained viscera may be tied off as the cord is ligated. If the base of the cord is large or cone-shaped, the cord should be tied at a safe distance, carefully asepticized, and a supporting soft pad worn from the first.

2. *Infantile umbilical hernia* is a small protrusion into a stretched umbilical cicatrix that frequently develops during the first year of life. The swelling is rounded or cylindric, easily reducible, and usually disappears by the age of three or four.

Treatment: A truss with a flattened pad, or a wooden button form covered by linen sewed to the belly-band or held over the opening by strips of plaster, may be used. If the condition is troublesome or persists beyond puberty (which is rare) umbilical herniorrhaphy is advisable.

3. *Umbilical hernia of adults* usually develops through the linea alba just above or below the navel, which becomes involved if a large sac is formed. Obese multiparous women are especially subject to these hernias, and usually have an associated diastasis of the recti. The opening is rounded, the sac large and often lobulated, with adherent contents of great omentum and frequently the transverse colon, small intestine, and occasionally the stomach. Those of large size may contain over half of the contents of the abdomen. The hernia is often incarcerated or obstructed. Incarceration or strangulation may occur in one loculus without involvement of adjacent hernial cavities. Umbilical hernia in adults tends to progressively increase in size, burrowing in the abdominal fat with the gradual compensatory reduction in the size of the abdominal cavity, so that finally the hernial contents cannot be returned to the abdomen without dangerous tension and secondary ileus.

Fig. 963.—Abdominal obesity and umbilical hernia.

Treatment.—Hernioplasty should be performed before the patient becomes too old or the hernia too large for reduction. Operation is also advised for strangulation or recurrent incarceration, which the patient may mistake for biliousness.

For a strangulated umbilical hernia of great size the constriction should be relieved, the ring of the sac widely opened to convert the sac and the abdominal cavity as far as possible into one large space, and the incision closed without attempt at a complete reduction or closure of the hernial ring. Later, after suitable reduction and preparatory treatment, hernioplasty may be done.

Palliative Treatment.—A large, strong abdominal band with a suitable pad of vulcanite or metal plate may be worn over the hernia. By diet and exercise attempts should be made to reduce the obesity, and to redevelop the muscles of the abdominal wall. Digitalization may be desirable on account of the degeneration of the cardiac muscle.

Operative Treatment.—In operating for umbilical hernia the great thinness of the overlying skin and fat is to be remembered.

Mayo's Operation (*Vertical Imbrication*).—A wide transverse ellipse of skin is removed, the sac opened, adhesions separated, bleeding vessels tied, the hernia reduced, and the edges of the ring and aponeurosis closed with a wide lapping or imbrication from above downward.

Babcock's Interdigitation Operation.—(1) The thin overlying skin is excised, usually by a wide vertical elliptical incision; (2) the body and neck of the sac are divided in the midline, and the con-

tents liberated and reduced; (3) the edges of the sac, and the adjacent stretched portions of the aponeurosis between the recti, are cut into horizontal ribbons; (4) the edges of the recti are united in the midline, by continuous or interrupted sutures of chromic No. 2 catgut; (5) the ribbons of aponeurosis and sac interdigitated from side to side are tacked in position by No. 1 chromic catgut, and the fascia and overlying skin carefully closed.

Repair by Layer Closure.—The hernia is reduced by open incision, the sac resected, the peritoneum, recti and anterior sheath of the rectus separated into their component layers, and united, the one to the other, with imbrication of the external sheath of the rectus.

In operating for umbilical hernia resection of adherent and hyperplastic omentum may be desirable, although it increases the shock of the operation. When strangulated, if the gut is gangre-

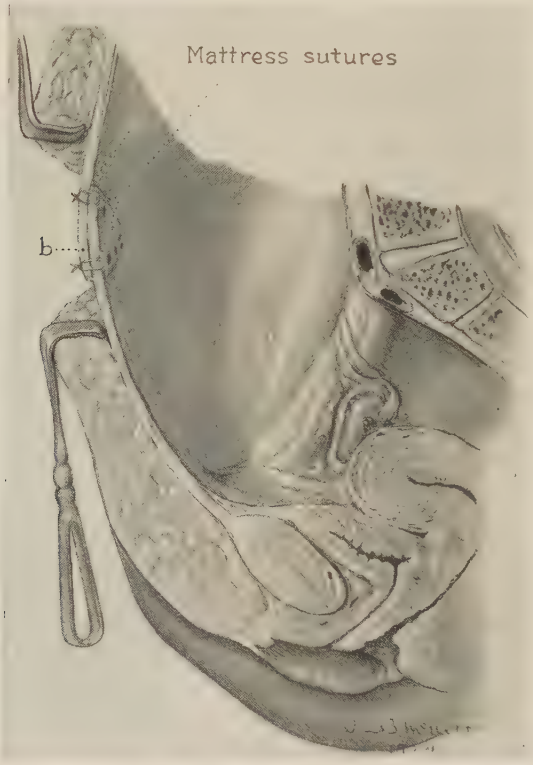


Fig. 964.—Mayo's operation for umbilical hernia by vertical imbrication of the abdominal wall (*a*, *b*).

nous, it should be resected and an artificial anus formed, the loop of the bowel being brought outside of the incision as in the first step of a Mikulicz colostomy resection.

Ventral Hernia.—A hernia of any part of the anterior abdominal wall, not involving the inguinal, femoral, or umbilical opening, is considered a ventral hernia.

Varieties.—(1) Median; (2) lateral, and (3) postincisional.

1. **Median Ventral Hernia, Divarication of Recti.**—Separation of the recti muscles between the navel and xiphoid occurs in young children, a protrusion resulting as the child strains. The condition is usually transient, disappearing as soon as the muscles develop and approximate. If large or progressive, a supporting belt or band should be worn, otherwise no treatment is required.

Subserous fatty protrusions forming small, but occasionally painful, irreducible, masses, are not infrequently found along the linea alba above the navel, especially in vigorous well-developed men. A hernia may be associated. The *treatment* is incision, removal of fat, and suture of the opening in the linea alba with imbrication.

Diastasis of recti muscles occurs along the linea alba, chiefly above the navel, but may involve the entire length of the recti. It usually occurs in multiparous women with marked abdominal relaxation.

Fig. 965.—Interdigitation of fascia in the treatment of diastasis of the recti. The peritoneum with the edges of the recti on the margins of the hernial opening are first united, and the redundant aponeurosis, or the hernial sac, split into ribbons, which are interdigitated, and fastened into position by suture. This gives a very strong support to the weak abdominal wall.

The test for the condition is to have the patient raise the body from the hips when supine. The linea alba then bulges forward between the recti. The relaxed abdominal wall favors ptosis of the viscera, uterine prolapse, rectocele, and cystocele. The *treatment* is the wearing of a wide supporting belt or, in severe cases, the imbrication or interdigitation of the stretched linea alba and the approximation of the recti.

2. **Lateral ventral hernia** is rare, but most common in the linea semilunaris at the junction of a line from the umbilicus to the anterior superior spine of the ilium, where the inferior epigastric artery pierces the abdominal wall. Much

more common are the hernias through the linea semilunaris described under Direct Inguinal Hernia.

Hernia in the linea alba especially occurs a short distance above the navel, *epigastric hernia*. The linea alba here forms a meshwork of interlacing fibers with horizontal meshes, through which the extraperitoneal fat may protrude (*properitoneal lipoma*) and drag behind it a funnel-shaped process of peritoneum. It is found in robust adult males, about the age of thirty, especially those engaged in hard manual labor, and may become strangulated.

3. **Postincisional Hernias.**—Incisional hernias result from: a. *Division of the intercostal nerves* at operation. This may be followed by paralysis and wasting of the supplied muscles, chiefly the rectus, with secondary thinning, distortion, and marked bulging of the abdominal parietes on strain. For this reason incisions crossing the lower thoracic nerves or those parallel with and lateral to the recti should be avoided as far as possible.

Fig. 966.—Hernial protrusion in a scar following operation for appendicitis with drainage.

b. *Suppuration or separation of abdominal incisions*, abscesses of the abdominal wall, degeneration, rupture, necrosis or abscess of the abdominal muscles, usually the recti (such as follow typhoid fever or pneumonia), may result in hernial protrusion. Drainage wounds through the anterior abdominal wall, particularly for appendicitis or suppuration in the pelvis, are common causes of incisional hernia.

Hernias following abdominal incision are usually adherent and often loculated. Adhesions frequently cause intestinal angulation or strangulation, the obstructed bowel often being within the abdominal cavity rather than in the hernial sac.

To prevent these hernias, muscle-splitting, anatomic incisions with avoidance of the intercostal nerves should, as far as possible, be used, particularly when drainage is required. Incisional hernias are so subject to dangerous complica-

tions that they should be corrected by operation. From retraction and loss of tissue, it may be necessary to reinforce a deep defect in the abdominal wall by a transplant from the fascia lata, or by the introduction of an alien substance such as silver filigree (Bartlett, 1903) or silver chain (Babcock, 1914). Both the filigree and chain may break after introduction from muscular strain, but this does not destroy their supportive qualities. The sharp ends of the broken filigree, however, often give later distress, and for this reason the chain is to be preferred. A fine lorgnette chain of sterling silver may be introduced by a needle in the deeper layers of the muscle or in the aponeurosis of the external oblique. From the greater pressure in the lower abdomen, hernias are more common after incisions below the navel.

Rare Hernias.—**Obturator hernia** occurs through the upper part of the obturator foramen, through the opening by which the obturator vessels and nerves pass out of the pelvis. This hernia is more common in women, due to their broader pelvis and larger obturator opening, and occurs especially after the age of fifty in those who have lost fat. After leaving the foramen the hernia may remain deeply placed between the obturator membrane and the obturator internus muscle, or pass over the muscle and be covered by the pectineus and adductor brevis.

Fig. 967. Deformity of the abdomen due to incisural hernia from a right pararectus incision.

Symptoms.—There is indistinct deep swelling in the upper part of the femoral triangle and, in some cases, a fulness below the pubic end of the inguinal ligament. With the limb flexed, adducted, and rotated laterally, the mass is felt on the medial side of the thigh behind the origin of the adductor longus. Occasionally there is paresthesia over the medial side of the knee, in the distribution of the obturator nerve. The internal obturator orifice may be explored from the rectum or vagina, and the diagnosis confirmed. As a rule, the condition is recognized from within the abdomen during an operation for intestinal obstruction.

Treatment.—Obturator hernia should always be treated by operation. The bowel may be reduced by a lower abdominal incision from within the pelvis, or an incision may be made over the upper medial part of the femoral (Scarpa's) triangle. In strangulation the constriction should be relieved by cutting candad and mediad, to avoid the vessels which lie laterally and anteriorly.

Lumbar hernia is a hernia passing out of the abdomen between the last rib and the crest of the ilium, as a rule through the lumbar (Petit's) triangle, which is bounded by the iliac crest below, the latissimus behind, and the external oblique in front. Lumbar hernia is more common in males and on the left side. It is usually soft, lobular, and easily reduced, but at times becomes strangu-

lated. It may result from wound, contusion, strain, lumbar abscess, or occur without apparent cause. It should be differentiated from a dumbbell-shaped abscess, which may give an impulse on coughing and be partly reducible.

Treatment.—Belt or operation. In operating the lateral edges of the lumbar triangle may in part be approximated, and the gap reinforced by turning up a flap of aponeurosis from below the iliac crest.

Sciatic hernia is a hernia leaving the pelvis through one of the sciatic notches. The opening may be superior or inferior to the pyriformis muscle and the gluteus maximus. The sac usually is small, deep, well covered by muscle, and not very obvious. The opening containing the protruding viscera may be found, and the diagnosis proved by a rectal or vaginal examination.

Perineal Hernia.—This hernia passes through the pelvic diaphragm and appears in the perineum, being divided into: (1) The rectal, which follows the rectum; (2) the vaginal, which follows the course of the vagina; or (3) the cystic, which follows the bladder or urethra. All are very rare.

Treatment.—Suprapubic incision with closure of the opening from above, associated with proctorrhaphy, sigmoidorrhaphy, perineorrhaphy or vaginal interposition of the uterus, as may be required in the particular case.

Retroperitoneal or **internal hernias** occupy the various recesses within the peritoneal cavity. They include: 1. Hernias of the epiploic foramen (of Winslow) and lesser peritoneal cavity.

2. Duodenal fossæ: (a) Inferior, (b) superior, (c) duodenojejunal fossa under the inferior mesenteric vein and the colica sinistra artery.

3. Cecal fossæ: (a) Cecal, posterior and lateral; (b) superior ileocecal; (c) the inferior ileocecal, which is the usual location.

4. Intersigmoid, at the root of the mesocolon of the left side.

5. Retrovesical, behind the bladder. These fossæ may be greatly deepened or distended, the hernia having the size of a cocoanut or adult head.

The *symptoms* are an indefinite intra-abdominal mass, with evidences of acute, subacute, or chronic obstruction.

On opening the abdomen a mass of intestine or other viscus, covered by a thin peritoneal membrane which may largely fill the abdomen, is found. The orifice or neck of the sac may be located with difficulty.

Reduction may be difficult, on account of adhesions and the small size of the opening. After reduction the opening should be closed. Despite efforts to close the opening, the hernia may recur with obstruction after operation. The sac should then be emptied again, and either the opening more securely sutured, or the sac packed with gauze until adhesions have formed.

Diaphragmatic hernia is a hernia passing through the diaphragm into the thoracic cavity, and is divided into: (1) The *congenital*, which has a sac, and the more common (2) *traumatic*, a false hernia or prolapse without a sac. The condition, as a rule, is on the left side, as the liver protects the right diaphragm. It usually passes under the lateral or medial lumbocostal arch (arcuate ligaments), with entrance of the stomach and transverse colon into the thorax.

Etiology.—One-sixth of the cases of diaphragmatic hernia are congenital, one-sixth acquired, and two-thirds due to traumatism either from a penetrating broken rib, an external agent, or rupture of the diaphragm from a sudden

greatly increased intra-abdominal pressure. Ten per cent. are of undetermined origin; 5 per cent. occur under ten years of age. "Eighty per cent. of the patients with traumatic diaphragmatic hernia give a history of symptoms for less than three years" (Hedblom).

Contents of the Sac.—The stomach, colon, less frequently the small intestine and spleen or any of the abdominal organs, except those of the pelvis, may pass through the diaphragm in diaphragmatic hernia.

Symptoms.—Abdominal symptoms include pain, vomiting, constipation, abdominal distention, and difficulty in vomiting or belching. The thoracic symptoms are pain, dysphagia, and dyspnea, and are more frequent. The physical findings are often indefinite, there being tympany and dulness to percussion, displacement of the heart, splashing and gurgling in the thorax, colicky pain, pain produced by eating, hematemesis, persistent belching or inability to belch, pain referred to the left shoulder, and gurgling and rumbling sounds of the chest with a feeling as if the stomach were being pulled up.

The hernial opening is central in 23 per cent., lateral in 29 per cent., posterior in 13 per cent., at the esophageal hiatus in 20 per cent., and parasternal in about 2 per cent.

Diagnosis.—The Roentgen ray is of great value.

Prognosis.—Obstruction usually develops sooner or later.

The operative mortality following laparotomy is about 40 per cent., and in cases without obstruction, about 20 per cent. The operative mortality following thoracotomy is 20 per cent. in obstructive and non-obstructive cases. Under twelve years of age, the operative mortality is 40 per cent. In about 12 per cent. secondary obstruction occurs, and in another 12 per cent. the hernia recurs (Hedblom).

Operation is desirable on account of the later tendency to obstruction, even though the symptoms are mild. If there is obstruction or abdominal symptoms, a celiotomy, reduction, and closure from below should be attempted. In recent cases, or those without obstruction, thoracotomy is preferred.

The hernial ring should be sutured or covered by a transplant of fascia or muscle. Suturing of the stomach to the abdominal wall and obturation of the hernial opening by an abdominal viscus should not be done, as it is frequently followed by a recurrence. Very large openings, from absence of the diaphragm on the left side, may be closed by a plastic operation following an extrapleural thoracoplasty of the lower thoracic wall, an extensive rib resection being the preliminary operation. At the completion of the operation air should be aspirated from the pleural cavity to prevent a reduction of the respiratory capacity below the limit of safety.

CHAPTER LVI

THE RECTUM AND ANUS

Congenital malformations include agenesis, atresia, stenosis, and stricture.

1. **Imperforate Anus.**—The rectum bulges on perineum when the infant cries or strains. Meconium is not discharged, and the abdomen progressively enlarges.

Treatment.—A small incision or puncture is made through the skin into the rectum, and the new anal opening cautiously dilated. Periodic dilatation may be necessary to prevent a stricture.

2. **Stricture of rectum** usually occurs where the anal canal joins the rectum. It is to be treated by graduated daily or weekly dilatation by the lubricated finger or a bougie.

Fig. 968.—Imperforate anus with vaginal cloaca in a child.

3. **Imperforate Rectum.**—A partition is found about 2 cm. above the anus. If the partition is thin, bulging is felt as the child strains.

Treatment consists in perforating the septum and dilating the opening.

Agenesis of Rectum and Anus.—The perineum does not bulge on straining.

Treatment.—Dissection in midline. If the lower end of rectum can be located, it is brought down and sutured to the skin of the perineum. If the colon ends at or near the pelvic brim, an inguinal colostomy is indicated which, however, has a high mortality in the newborn.

4. **Cloaca.**—The rectum opens into the bladder, vagina, urethra, or vulva.

Treatment is to maintain a free opening for feces to the perineum and, after the age of three, to reconstruct the parts by plastic operation. For success a preliminary, but temporary colostomy may be necessary to divert the feces.

Proctitis.—Inflammation of the rectum.

Etiology.—(1) Foreign bodies introduced or swallowed, as fish or meat bones, bits of wood, glass, bottles. (2) Parasites—thread-worms (*Oxyuris vermicularis*),

developing larvæ or grubs, bilharzia. (3) Traumatic injury with contusion or laceration—accidental, from introduction of foreign bodies, local examination, introduction of instruments, bougies, syringe nozzles, tubes, sexual perversion (sodomy), impacted feces. (4) Infection—gonorrheal, syphilitic, tuberculous, dysenteric. From piles, fissure or fistula, sprue, rectal prolapse, a polypus or tumor.

Symptoms.—Rectal tenesmus with bearing down and straining; pain, sense of weight and fulness in perineum, and the discharge of mucopus from the anus.

Treatment.—Remove the cause, such as foreign bodies or local irritating factors. Destroy parasites, Quassia injections for thread-worms, erasion of egg-containing polyps, for bilharzia; nitrate of silver or argyrol injections for gonorrhea; iodoform, ichthyol and guaiacol suppositories for tuberculous ulceration; the treatment of piles, fissure, and fistula. In severe cases, for better drainage, a divulsion or division of the sphincter ani or a colostomy may be desirable.

Incontinence of feces may be due to: (1) Paralysis as in spinal injury or disease; in coma, as in heat stroke, cerebral concussion, or diabetic coma. The sphincter control is often imperfect in tabes and spinal sclerosis. (2) Asthenic and general muscular weakness, as in debilitating diseases and senility. (3) Stretching, division or destruction of the sphincter muscles from childbirth, divulsion, operation, or other traumatism. Voluntary control depends upon the external sphincter.

Treatment is that of the underlying condition. With incontinence of feces, constipation should be favored by the use of a diet leaving little residue, and the administration of bismuth, ergot, astringents, and peristaltic sedatives. In children suppositories of ergot, and local injections of strychnin have been used. For extreme dilatation, division, or loss of the sphincter, a plastic operation or the transplantation of slips from the adjacent pubococcygeus or glutæus maximus muscle around the rectum, should be considered.

Fecal Impaction.—The rectum is distended by a firm fecal mass which causes a sense of fulness in the pelvis (*rectal tenesmus*). The condition is common in elderly persons and those of relaxed fiber, particularly when they are confined to bed by operation or disease. The diagnosis is readily made by a digital examination, and the mass should be broken up and removed digitally, or by other mechanical measures aided by enemas. Laxatives and enemas alone often fail to remove completely the hardened mass.

Anal and Rectal Abscesses.—*Varieties:* (1) *Cutaneous*, (2) *subcutaneous*, (3) *ischiorectal*. The ischiorectal may be deep, and *retrorectal*, *pelvirectal*, or *interstitial*.

Cutaneous abscesses involve the follicles about the anal margin, and should be treated by evacuation, frequent cleansing, the local application of calomel and bismuth ointment, the ointment of the yellow oxid of mercury or, if the skin is moist, by dusting with ABC (acid boric, 3; bismuth subnitrate, 2; calomel, 1 part) powder or thymol iodid. Attention should be given to the general health, and if the condition is persistent, sodium cacodylate and appropriate vaccines, usually of the staphylococcus and colon bacillus, should be given subcutaneously.

Subcutaneous abscess may be perirectal or perianal. The infection spreads by the lymphatics, forming subcutaneous and submucous or a submucocutaneous abscess.

Treatment.—Early incision and evacuation, local cleanliness and antiseptic applications (bismuth or yellow oxid-of-mercury ointment).

Ischiorectal abscess involves the ischiorectal fossa, the lateral wall of which is formed by the ischium lined by the obturator internus; the medial wall by the rectum, surrounded by the levator ani; the inferior wall by the skin, anteriorly the urogenital diaphragm (triangular ligament), and posteriorly the border of the gluteus maximus.

Etiology.—Local injury or infection. Wounds, foreign bodies, or a postoperative infection. The infection may come from: (1) The rectum, as an ulceration of rectal sinuses (crypts of Morgagni); (2) through the skin; (3) outer pelvic wall; or (4) urethra. The acute form usually is due to the colon bacillus, the chronic form to the Bacillus tuberculosis. A diffuse cellulitis, often gangrenous, occurs in the old and enfeebled.

Symptoms.—Chill or rigor followed by fever, increased pulse-rate, headache, rectal tenesmus, local violent throbbing pain. With the more superficial forms there is redness and swelling of the skin; in the deeper forms, swelling and induration are present. Marked tenderness and thickening of the tissues are detected by a finger in rectum. The pus may contain gas from the colon bacillus.

Diagnosis.—Local swelling, redness, induration, tenderness, later fluctuation. The abscess may break through the external skin or into the rectum, usually with a secondary fistula.

Treatment.—Free incision as soon as induration has developed, through the perineum external to sphincters. All pockets should be freely opened, the sphincter cautiously dilated after evacuating the abscess. The abscess cavity is wiped out with tincture of iodin and packed with iodoform gauze, which is removed in forty-eight or seventy-two hours, and the cavity then kept filled with bismuth paste. If the abscess has ruptured into the rectum, the opening should be freely enlarged outward, with division of the sphincter as for fistula.

In the after-treatment free drainage must be maintained, the parts kept clean, stimulated by an occasional application of tincture of iodin or nitrate of silver, and caused to heal from within outward to avoid a secondary fistula. A secondary operation may be required.

Retrorectal abscess may be due to necrosis of the pelvic bones, foreign bodies, a poorly drained internal proctotomy, infection from a fistulous tract, tuberculous lymph-nodes, rectal ulceration, gummata, or as a sequence to typhoid fever, pneumonia, and other general infection.

Symptoms usually are ill defined and with but mild constitutional disturbance, as malaise and slight temperature. There is aching and weight in the pelvis and sacrum, which may extend along the sciatic nerve; constipation, and often but little pain of defecation. The abscess which may be felt on deep rectal palpation, may open into the rectum, ischiorectal fossa, or upon the skin back of the sphincters, or rarely through the sciatic notch into the buttocks.

Treatment.—Evacuation by transverse or crescentic incision between coccyx and anus. Tonics, vaccines, and early ambulant treatment are helpful.

Pelvirectal abscess occurs from infection from the bladder, urethra, prostate, uterus, or broad ligament. It may follow a psoas abscess, necrosis of the bones of the pelvis, perinephritis, vesiculitis, appendicitis, diverticulitis, traumatism of the rectal wall, childbirth, or operations upon the uterus or prostatic urethra.

Symptoms are those of prostatitis, vesiculitis, posterior urethritis in men, or of an acute pelvic infection in women; with chills, fever, increased pulse-rate, aching pain, urinary obstruction, edema of the scrotum or vulva, pain in perineum and pelvis. At times there is a typhoid state with low fever, diarrhea, and mental depression. The abscess may perforate into bladder, rectum, or vagina, into peritoneal cavity, or from the iliac fossa it may point above the inguinal (Poupart's) ligament. The abscess is located by the finger introduced into the rectum or vagina.

Treatment.—Incision and drainage through perineum or ischiorectal fossa, with division of the pubococcygeus muscle on the side of the abscess, divulsion of the sphincters, and drainage by tubes and gauze. In the postoperative treatment irrigations, instillations, and injections of bismuth paste are used until healing has occurred.

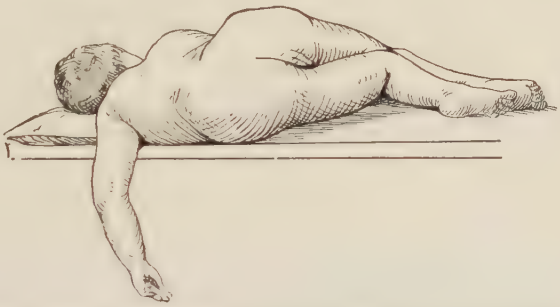


Fig. 969.—Sims' or the left lateral semiprone position, used for operations and examinations through the vagina and rectum.

Fistula in ano (*anorectal fistula*) is a term applied to any unnatural channel, sinus or fistula, in proximity to the anus.

Varieties.—The fistula may be: 1. Complete, with opening upon both rectum and perineum.

2. Incomplete—either (a) a blind external fistula opening upon the perineum only; or (b) blind internal fistula opening upon the rectum only.

The varieties are (1) anorectal, (2) rectovesical; (3) rectovaginal; (4) rectourethral, or (5) sacral sinus. The suppurating, granulating sinus, extending from the external opening, may partially encircle the anus or rectum (*horseshoe fistula*) and, like the abscess from which it originates, it may be submucous, ischiorectal, or pelvic.

Etiology.—(1) A pre-existing abscess, chronic irritation, or infection (especially tuberculous) persisting on account of its connection with the rectal or anal canal or other source; (2) a foreign body; or (3) suppurating crypts of Morgagni. Fistula in ano is a common complication of pulmonary tuberculosis, but also follows a general or local infection, including typhoid fever, dysentery,

smallpox, measles, scarlet fever, Bright's disease, diabetes, syphilis, pneumonia, and influenza.

Symptoms include: (1) History of preceding abscess; (2) pain on defecation which is variable; (3) persistent or intermittent discharge of pus, gas, or fecal material. In severe cases, fever, wasting, and asthenia occur.

Diagnosis.—Usually one or more small openings are found in perineum, from which pus may be expressed. The opening may show protruding granulation tissue, or be temporarily closed at the time of examination. By palpation with

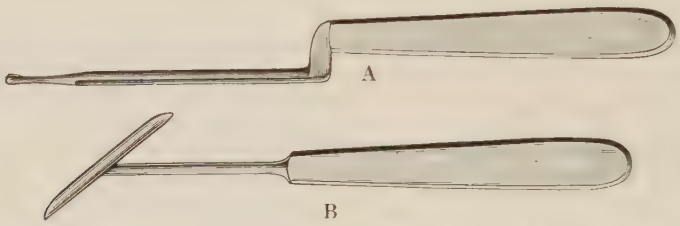


Fig. 970.—Collier F. Martin's straight probe-ended fistula director (A); angular fistula director for internal fistula (B).

finger in rectum, an indurated cord-like tract is felt, usually passing toward rectal mucosa. Gentle probing usually confirms the diagnosis.

Treatment.—Non-operative measures such as cleansing, cauterization, or injection of the tract give but temporary relief. For a cure an operation is necessary. Sacral, spinal, or ethylene anesthesia is preferred in the tuberculous. The tract is delineated by injecting a strong ethereal solution of methylene-blue,

Fig. 971.—Martin's rectal speculum (DaCosta's Surgery).

and is then by careful dissection, following every one of its ramifications, completely excised.

The operation will rarely be successful without division of the sphincters, which should be made at only one place. The anus and rectal wall should be freely laid open up to the highest internal opening. By first disinfecting the fistulous tract by swabbing with a saturated solution of zinc chlorid, and the

rectum by packing with gauze saturated with ½ per cent. solution of hydrochloric acid before injecting with methylene-blue, the perineal incision may be largely closed with silkworm-gut or silver wire. The upper margin of the rectal wound should, if possible, be brought down and sewed to the anal margin, taking care to leave the anal ring freely open and without pockets or recesses into which feces may collect. The small open wound at the anus is then packed with bismuth subnitrate gauze, and the external wound kept coated with a yellow oxid-of-mercury ointment. Primary union is usually obtained for four-fifths of the wound. If secondary pocketing of feces, inflammation, or infection follows, the stitches are to be removed, the wound tract laid freely open, packed, and caused to granulate from within out. The first bowel-movement is delayed, if possible, for four to five days. Complete excision is preferable to division of the fistulous tract and rarely is followed by a recurrence of the fistula provided the post-operative treatment is properly conducted.

The patient is permitted out of bed, usually, by the third to the sixth day. If secondary incontinence of the sphincter persists, a plastic repair of the sphincter may be made, preferably after a year.

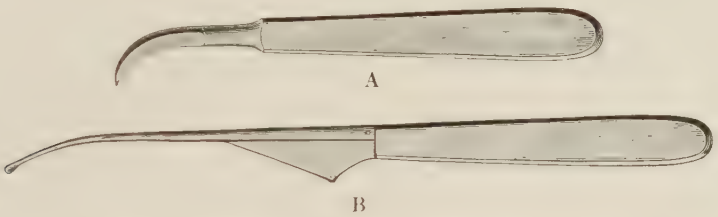


Fig. 972.—Collier F. Martin's sharp-pointed curved fistula knife (A); long probe-ended fistula knife (B).

Fissure in Ano (*Irritable Ulcer of the Anus.*—A longitudinal or oval ulcer in the anal margin characterized by spasm of the sphincter and pain after stool.

Pathology.—The ulcer is usually single, shallow, with sharply defined edges, in the midposterior line over the white line of Hilton, the base often exposing fibers of the external sphincter. Below the ulcer a tag of pushed-down mucosa (*sentinel pile*) is usually present.

Etiology.—A laceration and infection of the lining of the anus, from over-distention following constipation, examination, narrow anus, or child-bearing. It is more common in men than women.

Symptoms.—Severe burning pain during and after defecation, with tenesmus and the streaking of feces with blood. The pain usually develops with an interval after the stool.

Reflex Symptoms.—Dysuria, backache, pains down the leg, facial and occipital neuralgia, spinal irritation, temporary strabismus. Voluntary constipation results from fear of the pain.

Diagnosis.—As the patient strains, with the anal margins separated, the fissure is usually visible.

Treatment.—Mild laxatives and a diet to produce soft, non-irritating movements; cauterization of ulcer with liquefied phenol, followed by tincture of iodin. Suppositories of ichthyol, bismuth, hyoscyamus, tannic acid.

As the ulcer is aggravated by the spasm of the sphincter, healing will not usually occur until the muscle has been temporarily paralyzed. Under gas or ethylene anesthesia the sphincter is divulsed, the ulcer incised or excised, and cauterized. A partial or complete division of the external sphincter (*Boyer's operation*) is occasionally desirable.

After the operation the parts should be kept clean, the evacuations soft, and the wound stimulated by occasional applications of a 4 per cent. nitrate of silver solution and soothed by the use of 0.6 gm. ichthyol suppositories, or those containing phenol 0.02, ichthyol 0.3, bismuth subnitrate 0.6, and extract of hyoscyamus, 0.02 gm. Cellulitis, abscess, fistula, and stricture may follow as complications, and embedded foreign bodies (bits of bone, wood, nut shell) should not be overlooked.

Submucous fissure usually is an ulceration of the crypts of Morgagni, or cryptitis. The crypt should be exposed by dilating the anus, caught upon a small blunt hook, and freely opened or excised.

Hemorrhoids (*piles*) are varicose veins of the anal region.

Varieties.—1. External hemorrhoids involve the inferior hemorrhoidal veins, are covered by true skin, and may be (a) thrombotic or (b) hypertrophic.

2. Internal hemorrhoids are dilated superior hemorrhoidal veins and are covered with mucous membrane. A strawberry pile or rectal nevus may be present.

Hemorrhoids do not develop from the middle hemorrhoidal veins.

Etiology.—Increased pressure from the portal veins is favored by the lack of valves and the free anastomosis between superior middle and inferior hemorrhoidal veins.

Cirrhosis of the liver, intra-abdominal tumors, alcoholism, chronic constipation, and pregnancy are important causative factors.

Symptoms.—External piles consist of a central dilated vein covered by hypertrophic skin, and produce an external irreducible lump, with fulness, itching and but little pain, unless inflamed, thrombotic, or suppurating.

Treatment.—Astringent ointment, correction of constipation, dilatation of sphincter. The hard blue thrombotic pile or a suppurating hemorrhoid should be treated by incision or, better, excision with the removal of clots. This may be done under local anesthesia. Hypertrophic external hemorrhoids should be excised with the overlying hypertrophic skin-folds, after dilating the muscles.

Internal hemorrhoids develop within the sphincter, forming fleshy purple masses, consisting of varicose veins covered by hypertrophic mucosa, tending to bleed freely on defecation, to cause a mucoid discharge, and to prolapse through the anal ring. The patient to avoid discomfort often replaces the prolapsed mass after each stool.

Complications.—Thrombosis, inflammation, suppuration, secondary portal pyemia, prolapse with strangulation and sloughing, prolapse of the rectum, fissure in ano, cryptitis.

Diagnosis by inspection, palpation, inspection through a speculum. External hemorrhoids appear as a globular, oval, fleshy, purple or black tumor; internal hemorrhoids produce few symptoms except bleeding.

Treatment.—Internal hemorrhoids are treated by dilatation of the sphinc-

ters, exposure of the vascular pedicle by dividing the inferior mucous folds, the application of a clamp in the long axis of the bowel, the crushing of the pedicle and removal of the pile by the cautery (*clamp-and-cautery operation*). The less desirable ligature operation may be used, the base of the pile being ligated with silk or catgut, after incision or liberation and crushing.

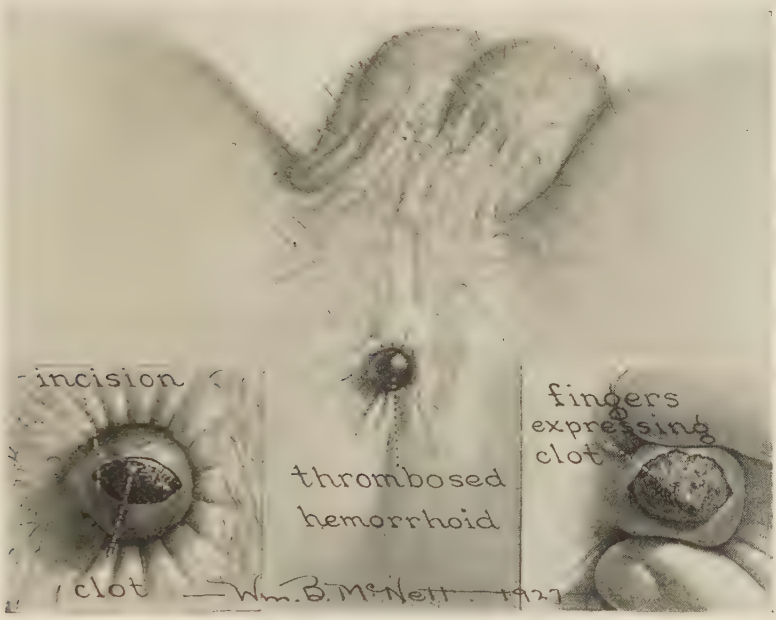


Fig. 973. Thrombotic (external) hemorrhoid. Under local anesthesia the mass may be incised and the clot expressed, or, better, the pile completely excised.

For internal hemorrhoids an ambulant treatment is occasionally used. The sphincters are first divulsed under gas anesthesia, and the cleansed piles later injected with a coagulating substance, such as 1 to 3 c.c. of a 5 per cent. solution of quinin and urea, or phenol Boboef, through a very fine hypodermic needle. It is best not to inject more than two hemorrhoids at one time. The ambulant treatment is inferior to the radical treatment by the clamp and cautery.

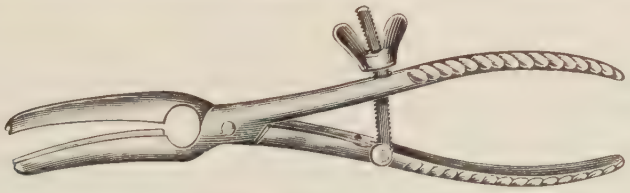


Fig. 974.—Kelsey's hemorrhoidal clamp.

Whitehead's operation, or excision of the pile-bearing area of mucous membrane, is used for a very extensive hemorrhoidal condition. The upper edge of the divided rectal mucosa is brought down and sutured to the anal margin after the excision. The operation may be followed by persistent ulceration, stricture, or stenosis of the anus, and is rarely to be used.

Procidentia Recti (Prolapse of the Rectum).—A protrusion of one or more coats of the rectum through the anal ring.

Varieties.—(1) Incomplete—only the mucous membrane protrudes; (2) complete—all the coats of the bowel protrude.

Incomplete prolapse occurs: (1) In children from straining at stool (as in dysentery) and from a poorly developed or weakened sphincter; (2) after rickets or scarlet fever; (3) in old age and after wasting disease with atrophy of fat and muscular tissues; (4) in middle age from the traction of protruding internal piles or polyps. Relaxed tissues, excessive straining (as from enlarged prostate, chronic constipation), diarrhea, dysentery, worms, piles, and polyps predispose to the prolapse.

Symptoms.—A protruding mass with central orifice, mucoid discharge, bleeding, at times incontinence of feces, rarely strangulation and sloughing.

Fig. 975.—Complete procidentia recti.

The protrusion may occur at stool or while walking about. From irritation and erosion, the mucosa becomes thick, hyperplastic, or ulcerated. There may be tenesmus and constant desire to defecate.

Diagnosis must be made from hemorrhoids, polyps, and intussusception. The corrugations (1) radiate from the central aperture in partial prolapse, but are (2) concentric from the wrinkling of the mucous membrane upon the muscular coat in complete prolapse.

Treatment.—1. Removal of any underlying cause such as polyps, piles, constipation, dysentery, worms, or enlarged prostate.

2. Improvement in the general health with increase of adipose tissue.

3. Prevention of prolapse, especially in children, by a narrow toilet seat,

strapping the buttocks together, or by defecation in the recumbent or lateral position.

4. Local measures, as one or more of the following: (a) Astringent suppositories and injections; (b) submucous injections of 1 to 4 c.c. of 2 per cent. quinin and urea, 12 to 20 per cent. phenol or 50 per cent. phenol Boboef to produce adhesions between mucosa and muscularis; (c) vertical radiating lines of cauterization through the mucosa to the submucosa; (d) removal of vertical folds of mucosa with the clamp and cautery.

Complete prolapse (*rectal procidentia*) is common in children from the stretching or giving way of the normal supports of the rectum.

1. *Rectal-sphincteric (or First Degree Procidentia).*—The internal sphincter prolapses with the rectum, so that there is no constriction between the skin and the protrusion.

2. *Rectal (Second Degree).*—The rectum prolapses through the internal sphincter, the protrusion being covered by mucous membrane, and a distinct groove or suture marking the anus.

3. *Rectorectal (Third Degree).*—Intussusception of the upper rectum into the lower, which does not protrude externally.

4. *Archocele (Rectal Hernia).*—The small intestine or other abdominal contents protrude through the rectovesical or Douglas' pouch, and carry the anterior rectal wall through the anus. This may be associated with a large prolapse.

If over 8 cm. of bowel is prolapsed, a double fold of peritoneum usually enters the mass and may be opened in operating.

Symptoms.—Protrusion at stool and difficulty in maintaining reduction, with ulceration, bleeding, thickening of rectal mucosa, constipation, weight in the pelvis, tenesmus, frequent and incomplete evacuations. When of the third degree, there is difficulty in completely emptying the rectum.

Treatment.—1. *Reduction:* If large the knee-chest position is used, aided by the application of hot compresses and gentle taxis.

2. *Operative Treatment.*—(a) Linear cauterization or scarification; (b) clamp and cautery; (c) excision of rectal mucosa (*DeLong's, Lorimer's operation*), resembles the Whitehead operation. (d) Rectopexy, proctopexy: A semicircular incision is made between the coccyx and posterior margin of external sphincter, and the rectum loosened from the sacrum and coccyx to the reflection of the peritoneum, without injury to the lateral rectal ligaments, clearing the posterior wall of rectum and the anterior wall of sacrum. The rectum is envaginated through the incision by an assistant with his fingers through the anus and interrupted silkworm-gut sutures are introduced at the sides of the sacrum and coccyx, catching about one-third of the circumference of the rectum. The ends of the suture are tied across the sacrum over a pad, pulling the rectum up and back into the hollow of the sacrum. The bowels are moved by enema on the sixth day, and the sutures removed on the tenth or twelfth day. The operative effect may be increased by plaiting the enlarged rectum by suture (*proctorrhaphy*). (e) Sigmoidopexy (Colopexy): Suture of the pelvic colon and sigmoid flexure to fixed pelvic structures or the abdominal parietes through a low abdominal incision is indicated in prolapse of the third degree.

Moschcowitz's Operation: The rectum, pulled taut through an abdominal

incision, is so sutured to the pelvic fascia so as to obliterate the culdesac of Douglas.

Amputation of the prolapse may open the peritoneum to infection, lead to injury of small intestines, be followed by the formation of a stricture, and should only be employed when gangrene has occurred.

Pruritus ani refers to itching about anus.

Etiology.—(1) Local irritation, in children usually is due to seat-worms; in adults there usually is associated moisture from disease of the skin, anus, rectum, or vagina. Local irritation occurs from pediculi, seat-worms, eczema, dermatitis, fissure, hemorrhoids, fistula, cryptitis, leukorrhea, gonorrhea, malignant disease, foreign bodies, constipation, neoplasms, syphilis. (2) Constitutional causes, especially diabetes, hepatitis. (3) Reflex causes as urethral stricture or inflammation, phimosis, enlarged prostate, stone in the bladder, pregnancy.

Symptoms.—Intense itching, worse at night or after stool, beginning at the anal margin and extending along the median raphé in front and behind. It is intermittent or continuous, and is more common in men than in women. The skin shows thickening, keratosis, fissures, ulceration or eczema.

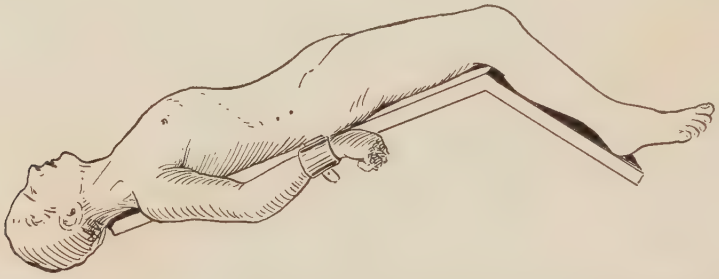


Fig. 976.—Trendelenburg's position used for operations upon the lower abdomen and pelvis.

Treatment.—(1) Improvement in the constitutional condition, especially in diabetes; (2) relief of local irritation as from parasites; (3) elimination of cryptitis, leukorrhea, or other discharge; (4) locally, a 10 per cent. solution of nitrate of silver may be applied every fourth day. Lotions of boric acid, aluminum acetate, lead acetate, or black wash are of value. If the skin-surface is moist, it should be kept dry by dusting-powders, such as zinc stearate, bismuth subcarbonate or subnitrate or A. B. C. powder.

Ball's operation, the raising of a flap of skin around the anus by dissection to divide the sensory nerves, is rarely to be considered.

Stricture.—The anus, rectum, or sigmoid may be narrowed or strictured (a) by congenital malformation, inflammation, or new-growth (*organic stricture*); or (b) by muscular spasm (*spasmodic stricture*, *functional stricture*).

Stenosis or complete obstruction of the rectum is due to conditions of the rectal wall obliterating the lumen or to pressure from without, as from pelvic inflammatory or neoplastic masses.

Inflammation and ulceration limited to the mucosa does not produce stricture, the submucosa and deeper coats must be involved. The rectum shows a marked tendency to stricture after division and suture, more so than any other portion of the intestinal tract. Inflammatory or fibrous stricture is usually due

to syphilis, and especially affects elderly women. It may also follow ulceration from dysentery or a tubercular proctitis, or extension of an adjacent inflammatory process.

Pathology.—The narrowing usually occurs within 2 or 3 inches of the anus, and is annular, tubular, or valvular. The bowel above is dilated, hypertrophied, and at times ulcerated.

Etiology.—(1) *Traumatic strictures* follow injury, as from foreign bodies, operation, or childbirth; (2) *inflammatory strictures* are secondary to abscess of the seminal vesicles, prostate, or other pelvic organs, to syphilitic or tuberculous ulceration or other forms of destructive proctitis; (3) *malignant strictures* usually are due to carcinoma.

Symptoms.—(1) *Ulcerative* and *inflammatory period* is characterized by dysentery, tenesmus, diarrhea or constipation, and a mucopurulent or bloody discharge; (2) *latent period* is marked by gradually increasing constipation; (3) *obstructive period* by diarrhea, obstipation, straining, indigestion, flatulence, distention, colic, pigmentation of the skin, chronic intestinal obstruction, ischiorectal or pelvic abscesses, or large fecal abscesses in the buttocks.

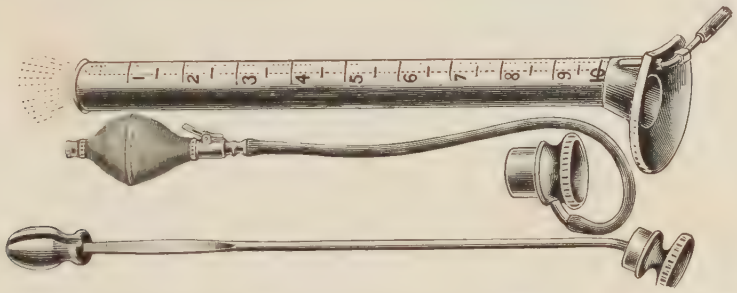


Fig. 977.—Pennington's proctoscope with arrangement for air inflation and electrical illumination.

Diagnosis is made by the finger, proctoscope, and Roentgen study after a barium enema. Deformed, *ribbon* or *pipe-stem* stools are rather rarely noted in the lower forms of stricture.

Prognosis.—Unfavorable as the stricture tends to persist or recur after dilatation, division, or excision.

Treatment.—*Operation:* Gradual dilatation by finger, bougie, or sound. With the higher strictures there is great danger of perforating or rupturing the intestines. In the lower 8 cm. a posterior *proctotomy* or incision followed by gradual dilation may be tried. In severe persistent forms a *proctectomy* is indicated; the upper end of the rectum above the stricture being brought down through the denuded sphincters and sutured to the skin, as in the operation for carcinoma of the lower rectum. For the higher strictures of small caliber a palliative colostomy is the safest treatment. Any associated constitutional affection, such as syphilis or tuberculosis, should be treated.

Syphilis of Rectum and Anus.—(1) *Primary lesion (the chancre)* rarely involves the anus; (2) *secondary lesions* (mucous patches and condylomas) are frequent about anus and perineum; (3) *tertiary lesions* (in the form of gummata) develop in the submucous tissue of the rectal walls, ulcerate, forming a deep

painless ulceration that may extend to the anus, sigmoid, vagina, perineum or bladder, with secondary fistula or, usually, an extensive persistent stricture. The condition is more common in elderly women than in men.

Symptoms.—Early pain, rectal tenesmus, bloody, watery, mucoid or purulent discharge through the anus; followed by increasing obstruction, and constipation or diarrhea.

Treatment.—(1) Active systemic treatment; (2) gradual dilatation of stricture by the finger or bougie; (3) daily insufflation through an open proctoscope of calomel and bismuth powder, or the use of calomel and bismuth suppositories. In severe cases a temporary or permanent colostomy or, rarely, rectal excision is desirable.

Benign Epithelial Tumors of the Rectum.—Mucous Polyp or Adenoma.—Adenomata may be pediculated or sessile. Broad flat sessile growths usually occur in lower third of rectum along the posterior raphé. They are red, vascular, single, 1 or 2 cm. in diameter, and occur chiefly in children and young adults.

Symptoms may be absent, or if irritated, tenesmus, hemorrhage, protrusion from the anus, and malignant degeneration occur.

Diagnosis is made by digital examination, proctoscopy, and biopsy.

Treatment.—Ligation of base and excision, division of base by cautery; fulguration or electrical desiccation.

Papilloma of the rectum is rare, and occurs as a soft reddish tumor on a short broad pedicle, with fine thread-like processes and vascular, normal or adenomatous, mucous membrane. It develops in adults between the ages of forty and sixty, affecting both men and women, and rarely becomes malignant.

Symptoms.—Rectal hemorrhage, diarrhea, prolapse of the rectum.

Treatment.—Excision or cautery destruction.

Carcinoma.—**Varieties:** (1) *Scirrhous carcinoma* (scirrhous cancer) leads to contracture and stricture, and is the most malignant and the second most common form; (2) *squamous epithelioma* develops from the anus, is rather rare, and is second in malignancy; (3) *adenocarcinoma* (columnar or cylindric cell epithelioma, malignant adenoma) is the most common type and is third in malignancy; (4) *medullary carcinoma* (encephaloid carcinoma) forms a large soft mass with a tendency to ulceration and necrosis; (5) *colloid carcinoma* is relatively benign.

Seat.—Below the descending colon the distribution of cancer is as follows: Sigmoid flexure, 16 per cent.; sacrococcygeal portion, 56 per cent.; prostatic portion, 19 per cent.; anal portion, 10 per cent.

Etiology.—(1) Hereditary predisposition; (2) age between forty and sixty years; 3 per cent. occur under the age of twenty; (3) male sex (60 per cent.); (4) conditions producing chronic irritation of the colon and rectum, such as mucous or membranous colitis; polyps or adenomata, chronic constipation or dysentery, and ulcerative colitis predispose to carcinoma.

Symptoms.—Early morning diarrhea, constipation, rectal tenesmus or colicky pain, abdominal cramps, acute intestinal obstruction, offensive bloody and purulent stools; and in the terminal stages, wasting and cachexia.

Complications.—(1) Stricture and atresia of the bowel; (2) fistula into abdominal wall, bladder, other portion of the intestinal tract, or elsewhere; (3) secondary abscess, extensive ulceration, rectal hemorrhage; (4) involvement of

postrectal, sacral, and lower aortic lymphatics, peritoneum, and liver. From an anal carcinoma extension occurs to the inguinal lymphatics.

Diagnosis.—Rectal palpation usually detects an infiltrating, ulcerating, or fungating growth, with thickened borders and peculiarly offensive hemorrhagic and purulent discharge. In the later stages the growth becomes fixed to adjacent organs, and the enlargement of the liver with umbilicated nodules and ascites indicates that the disease has passed beyond the eradicable stage. The enlarged sacral and perirectal lymphatics may be palpable. A proctoscopic or a Roentgen examination after a barium enema may reveal a tumor that cannot be reached through the rectum by the examining finger.

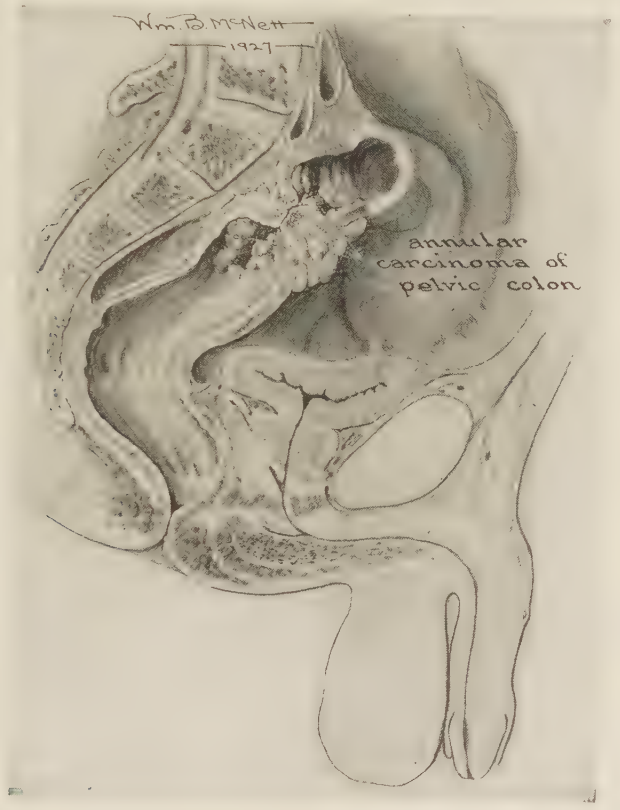


Fig. 978.—Annular scirrhous carcinoma of the pelvic colon producing intestinal obstruction.

Treatment.—1. Palliative: Colostomy puts the diseased portion of the intestine at rest, reduces the local irritation and discharge and thus retards the growth, prevents or overcomes intestinal obstruction and prolongs life. Radium and Roentgen radiation are rarely effective, may stimulate the local growth and increase the pain. A bland diet, and local cleansing, detergent or antiseptic irrigations are of some value. Anodynes and hypnotics by suppository, mouth, or hypodermic injection, usually are required in the later stages of the disease.

2. Radical Extirpation: Indicated if metastasis has not occurred, if the growth is movable, and has not invaded adjacent important structures.

(a) *Perineal excision* is useful for growths extending not over 5 cm. above the anal margin. The anal ring and perineum are sufficiently divided to give free exposure, and the growth with a margin of at least 3 cm. of healthy tissue removed. The liberated upper margin of mucous membrane is sutured to the anal opening.

For an annular growth a telescopic excision may be made, the upper margin of the rectum being brought down and sutured through the denuded sphincters to the anal margin, provided the sphincters are not diseased.

Annular resection and suture of rectum above the sphincters should not be practised, as secondary stricture is almost invariable. As a rule, closure of the divided sphincters is deferred for ten to twelve months to promote drainage and healing.

(b) *Vaginal excision:* In women growths not over 9 cm. above the anal margin may be exposed and resected by dividing the posterior vaginal wall, portions of which are excised *en masse* with the rectal growth. After the excision the opening in the posterior vaginal wall is closed by suture. The proximal end of the rectum is brought down and sutured as close to the anal margin as possible.

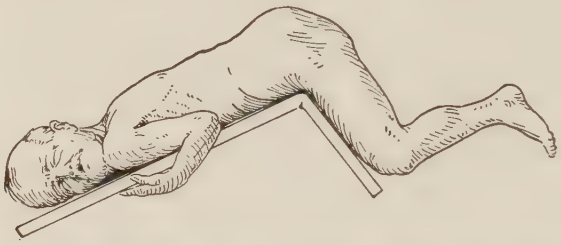


Fig. 979.—Inverted Trendelenburg position used in Kraske's operation and certain other operations upon the rectum.

(c) The *sacral* or *Kraske operation* gives a better exposure for the higher rectal growths. The patient being prone and in an inverted Trendelenburg position, a median incision is made from the anus nearly to the base of the sacrum. The coccyx and lower two segments of sacrum are excised, giving access to the pelvis. The lateral and other attachments of the rectum are divided as near the pelvic wall as possible, the vessels ligated, the peritoneum opened, the sigmoid mobilized, and a sufficient length of rectum with attached cellular tissue and lymphatics pulled through the incision for the section of the bowel, 9 cm. above the growth. The operation may be completed by: (a) closing the peritoneum, introducing a drain, and *restoring the anal opening* (the proximal stump of gut is pulled through the denuded anal ring, and sutured to the anal margin). This operation usually fails, due to necrosis of the bowel from interference with the vascular supply to the lower portion of the intestine; (b) *sacral anus:* An artificial anus is formed close to the divided sacrum. A sacral anus, while less conspicuous, is more difficult for the patient to care for than an abdominal artificial anus; (c) *lumbar* or *abdominal anus* is formed at an operation previous to that for resection of the tumor. This is the preferable method, and avoids contamination of the lower wound by feces.

Combined sacral and *abdominal route* is preferred for the higher rectal growths. The gut is divided well above the growth, the distal end closed by an inverting or a purse-string suture, and an artificial anus formed with the proximal end. The involved portions of the colon and rectum with the adjacent lymphatics are liberated from above, the blood-vessels ligated, the liberated mass placed in pelvis and covered by peritoneum, to be later removed from below.

A. Coffey's operation for *carcinoma of the lower rectum* consists of: (1) Long vertical lower right rectus incision with determining abdominal exploration; (2) guided by hand in abdomen, a rectal tube is passed through the growth into sigmoid, using Trendelenburg's position, other viscera being carefully walled off by moist gauze. The lateral mesosigmoid is divided, and the incision continued around the rectum, between bladder and rectum or uterus and rectum. The inferior hemorrhoidal vessels are divided between ligatures, those of the sigmoid clamped, cut, and tied. Fat and connective tissue and lymphatics are separated from the hollow of the sacrum by the hand, and the sigmoid divided by a cautery between clamps. The upper end of bowel is passed through a $3\frac{1}{2}$ cm. left rectus incision below the level of the navel, to form an artificial anus. The clamp is left on the proximal segment for twenty-four or forty-eight hours. The distal end of the sigmoid may be closed by purse-string suture, and fastened by a strong suture through the eye of the rectal tube. The adjacent mesenteric fat having been separated, by traction on the tube the sigmoid is inverted through the anus and the protruding ends clamped. For drainage a cigarette-drain is inserted in men, or a drain through the posterior vaginal wall introduced in women, to the hollow of the sacrum back of the inverted rectum. A peritoneal diaphragm is formed by suture to separate the general peritoneal cavity from the drained area of the pelvis, and the abdominal wound closed.

At the second stage of the operation the liberated rectum and sigmoid are removed from below by slitting the vagina, dividing the perineum, and if necessary removing the coccyx.

B. For *carcinoma of rectosigmoid* or *upper rectum* (Coffey) the sigmoid and pelvic colon are mobilized as in the preceding operation down to the end of the coccyx and prostate, and an abdominal anus formed by the clamp as previously described. The lower rectum is divided by a cautery between hysterectomy clamps at least 5 cm. below the growth, and the liberated bowel removed. The lower clamp is left on for forty-eight hours, protected by a large cigarette-drains. At a later stage the anus and lower rectum is removed from below.

Mortality, 6 to 16 per cent. Mortality of Kraske's operation, 12 to 15 per cent. In about 25 per cent. recurrence does not follow. The mortality of individual operators is influenced greatly by their conservative tendencies or special skill.

Sarcoma of the rectum or **anus** is relatively rare. The treatment resembles that for carcinoma, but radiation is a more valuable palliative measure.

CHAPTER LVII

THE GENITO-URINARY ORGANS

KIDNEY

Congenital Anomalies.—(1) *Hypoplasia*—one kidney is often small and rudimentary, the opposite kidney being proportionately enlarged; (2) *agenesis*—absence of one kidney (single kidney) is not unusual; (3) *fetal lobulation* persisting to adult life is unimportant; (4) *fusion of the kidneys* results in a solitary kidney or usually a *horseshoe-kidney*, the two organs united at their lower pole lie, as a rule, near the sacral promontory. Fusion into a disk or S-shaped organ in the lumbar region, or in the pelvis, also occurs. With fused kidneys both ureteral orifices may be normal, and functional. For an accurate diagnosis, without operative exposure, pyelography is necessary. Partial or complete *double ureter* often occurs and *congenital stricture of the ureter*, either single or multiple, is not uncommon. Supernumerary vessels are frequently found. The accessory renal artery usually leaves the aorta below the main renal artery, and may kink the ureter. Accessory vessels often enter the kidney at the poles, and may cause severe hemorrhage in the liberation of the organ.

Displacements of the Kidney.—(a) The kidney may be fixed, usually over the sacro-iliac joint (*pelvic kidney*), where it may be mistaken for a tumor; or more rarely near the abdominal inguinal ring, to which it is diverted by the descent of the testis. Displacement may be associated with pain, especially during menstruation. (b) Movable or floating kidney.

Cystic disease, hydronephrosis, and *sarcoma* may be congenital.

Examination of the Kidney.—*Palpation* is made with the patient lying upon the back, with the head, chest and knees elevated to relax the abdominal walls, and to obtain the effect of gravity upon the kidney. One hand is placed posteriorly over the loin, the other under the anterior costal margin, and the patient is encouraged to relax the abdominal muscles and take deep inspirations. Normally the kidney is not palpable or merely the lower pole is felt on deep inspiration. The patient may stand up, leaning forward, supporting the upper body on the arms (*Noble's position*). An enlarged or thickened ureter may be palpable through the vagina, rectum, or thin abdominal wall. Rarely, in emaciated patients, stones have been palpated in a thinned and diseased kidney.

The not uncommon horseshoe-kidney may often be felt over the pelvic brim or sacrum. From a bimanual examination it has repeatedly been mistaken for a pelvic tumor. Before removing a kidney, the presence of an opposite functional kidney should always be proved.

Rigidity of the lumbar muscles is found with injury or disease of the kidney. The patient should sit up with the body bent forward, the arms even and relaxed, and a careful comparison of the two sides should be made by light palpation.

Tenderness.—Unilateral tenderness on percussion over the kidney with the fist (*Murphy's fist-percussion*) is usually present with a unilateral inflammation of the kidney. *Percussion* may be performed, especially after distention of the colon with air. The enlarged kidney lies lateral and posterior to the colon. Enlargement of the kidneys is first noticed in the loin, and progressive enlargement continues to produce a fulness in this region. In other words, a large abdominal mass, which cannot be felt in the loin, is probably not renal.

Differential Diagnosis.—Renal swellings produce fulness without bulging in the loin, grow forward, reaching the anterior wall at the level of the navel. The colon lies in front, there is no space or resonance between the tumor and spine; and if not fixed by adhesion or size, the mass may move with respiration. It is usually unilateral, does not invade the pelvis and, on palpation, is separable from the liver by a line of resonance. The hilum may be palpable, urinary changes and an acute varicocele may be associated. The *liver* enlarges from behind the ribs, without space between the mass and the ribs, and lies anterior to the intestines, without mass or dulness in loin. The *spleen* has a sharp or rounded edge, a deep notch, greater movement with respiration, develops from behind the left lateral costal margin, and is not covered by intestine. There is resonance and absence of a mass in the loin.

Ovarian tumors invade the abdomen from the pelvis, the intestinal resonance is lateral and posterior, and an attachment exists to the uterus.

Hirschsprung's disease occurs in childhood. The mass is firm and doughy, from the fecal distention, and is associated with a history of chronic constipation.

Perinephric or *paranephric tumors* bulge into loin, are fixed, and are not palpable anteriorly.

Enlarged gall-bladder extends from under the right costal margin, from which it cannot be separated, moves with respiration, is cephalad to the colon, and produces no mass or dulness in loin.

Urinary Changes.—1. Hematuria (blood in the urine) may come from the vagina, urethra, bladder, ureter, prostate, or kidneys:

(a) *Urethral hematuria* occurs from stone, instrumentation, acute urethritis, and new-growths. The blood escapes without urination or with the first urine passed, the final urine being clear. No blood is found in the catheterized specimen.

(b) *Prostatic hematuria* results from prostatic calculus, traumatism, inflammation, or new-growth. The blood may flow back into the bladder. The urine contains clots, and most of the blood is passed at the end of micturition.

(c) *Vesical hematuria* occurs from papilloma, carcinoma, or other growths of the bladder, stones or other foreign bodies, ulceration of the bladder; or contiguous inflammation involving the bladder, such as acute appendicitis, or ruptured intestinal ulcer with peritonitis. The urine contains clots, and most of the blood is passed at the end of urination.

(d) *Ureteral hematuria* results from instrumentation, calculus or other trauma, inflammation, or neoplasm. The bleeding is usually slight, and the blood may be associated with an excess of ureteral epithelial cells. The blood-clotting in the ureter forms fine worm-like casts.

(e) *Renal hematuria* occurs in the so-called *essential hematuria*, from

calculus or other trauma, from tuberculosis, papilloma of the renal pelvis, or tumors of the kidney substance. A moderate, often microscopic hematuria following renal colic suggests calculus. In renal hemorrhage the urine is usually acid, and the blood is intimately mixed with the urine; or, if bleeding is from one kidney, the blood may collect in the trigone so that the urine first passed is the most colored. In hemorrhage from the substance of the kidney, blood-casts from the renal tubules are found in the urine.

Hematuria occurs in severe bacterial infections, as in sepsis, smallpox, measles, scarlet fever, yellow fever, typhoid, malaria (*black-water fever*), plague, pneumonia; in blood diseases, as scurvy, leukemia, purpura, hemophilia, jaundice; from poisons, as mercury, lead, arsenic, cantharides, turpentine, quinin. Bilharzia hæmatobia and other tropical parasites, rarely vicarious menstruation, especially malingering may also be responsible for blood in the urine.

2. Hemoglobinuria (the *passage of hemoglobin* without corpuscles) occurs in angioneurotic edema, Raynaud's disease, purpura, in conditions with extensive hemolysis, as from burns, freezing, blood-effusions, transfusion, paroxysmal hemoglobinuria and from certain hemolytic poisons, as snake-venom, ether, chloroform, phosphorus, carbolic acid, or carbon monoxid.

3. Pyuria (*pus in the urine*) may be derived from the vagina or any portion of the urinary tract, including the kidney, ureters, bladder, prostate, or urethra.

Fig. 980.—Brown-Buerger convertible, catheterizing, operating, and examining cystoscope, size No. 24 F.

(a) *Prostatic* or *urethral pyuria* is shown by the two- or three-glass test, the pus being found in the first portions of urine voided, or after prostatic massage.

(b) *Vesical pyuria:* The urine is usually alkaline, while in renal pyuria it is acid. The source of the pus is more accurately determined by the cystoscope, urethroscope, and ureteral catheter.

4. Chyluria follows obstruction of the thoracic duct from tumor, pressure or filaria.

5. Anuria results from cessation of renal function or an obstruction of the renal pelvis or ureter. An obstruction upon one side may produce reflex anuria with arrest of excretion of the opposite kidney.

Non-obstructive anuria (suppression of urine) may be reflex following operations or injuries of the genito-urinary apparatus, or be caused by *degenerative changes in the kidneys* in which uremia accompanies or precedes the anuria.

6. Pollakiuria (abnormal frequency of urination) expresses an irritation along the urinary tract, or a reflex or functional condition.

7. Dysuria (painful urination) may be produced by calcareous, inflammatory, neoplastic, and obstructive diseases chiefly of the bladder, prostate, and urethra.

8. Nycturia (urination at night) occurs under conditions that lead to pollakiuria. It is especially frequent in prostatic hypertrophy.

Roentgen study, after introducing an opaque catheter into the renal pelvis, or after distending the pelvis with solutions opaque to the rays (*pyelography*), shows the location, shape, contour of the ureter, pelvis, and primary and secondary calices, and their relation to other opaque objects such as calculi, phleboliths, calcified mesenteric tubercles. Solitary and ectopic kidney, horse-shoe-kidney, the location of renal or ureteral calculi, forms of ureteral obstruction and dilatation, certain diseases, and tumors of the kidney and renal pelvis are also shown on the pyelogram.

Pyelography.—A No. 5, 5½, or 6 ureteral catheter is introduced into the renal pelvis, and a 12 per cent. solution of sodium iodid injected by gravity from a height of 30 to 60 cm. When the pelvis is distended the film is exposed with the fluid running. A second picture of the ureter is made with the fluid running, as the catheter is withdrawn to the lower ureter. Bilateral pyelograms as a rule should not be made at the same time. Pyelography should not be used when the diagnosis may be made by simpler measures. If the renal pelvis or ureter is occluded pyelography is useless.

Hydronephrosis causes great enlargement of the pelvis with dilatation of the major and minor calices.

Tumors of the pelvis and hypernephroma produce filling defects. In polycystic disease, bizarre forms of pelvis from compression and distortion occur (*dragon pyelogram*) with great bilateral elongation, distortion, and encroachment of the entire kidney upon the pelvis and calices, the minor calices showing little distortion.

Tuberculosis begins in the parenchyma of the kidney as small abscesses, which expand centrifugally and finally erode the outer margin of the minor calices, causing irregular or fine tooth-like projections on the pyelogram. The presence of a filling defect in the pelvis is typical of a neoplasm, if one can exclude blood-clot and fibrinous exudate.

Retroperitoneal neoplasms and cysts may displace the catheter medially or laterally, with little change in the renal pelvis or calices.

Pneumoradiography.—The injection of air into the kidney, for better delineation on the film, may cause severe pain and emphysema, and should rarely be used.

Cystoscopy reveals the lining and contents of the bladder, the ureteral orifices and their movements, and the character of fluid discharged from each orifice.

The ureter exposed by operation is identified by the sliding peristaltic waves (*trombone action*) which are intensified by stroking the tube.

Renal Function.—One-third of a single kidney is sufficient to support life. Normally the kidneys excrete from 500 to 700 c.c. of urine daily, containing from 12 to 15 gm. of urea and 5 to 6 gm. of chlorids. A reduction below 30 per cent. of these quantities suggests renal insufficiency. By the ureteral catheter, 1.2 gm. of urea is normally obtained from a single kidney in two hours. A reduction below 0.75 gm. suggests unilateral insufficiency.

Indigo-carmin Test.—Four cubic centimeters of a 4 per cent. solution of indigo-carmin is given by intramuscular or intravenous injection, the blue appearing in the urine within seven minutes if

given intravenously, or within half an hour if given intramuscularly. It disappears from the urine in twelve to twenty-four hours. Renal insufficiency is indicated by a late appearance of the blue color, deficient concentration, or elimination lasting more than three days.

Chromocystoscopy.—After the indigo-carmin injection, the dye appears as a blue stream from the ureteral orifices within five to twenty minutes. Absence of elimination on one side indicates obstructive or destructive lesion, or absence of the kidney.

Phenolsulphonephthalein Test. Six milligrams are injected intramuscularly, and the amount excreted within two hours (normally 60 per cent.) estimated by colorimetric methods.

Phloridzin Test.—A subcutaneous injection of 15 minims of 0.5 per cent. solution of phloridzin is given. Normally sugar is found in the urine in thirty minutes, the excretion continuing for four hours, with the elimination of 0.5 to 2.5 gm. A diminished or delayed excretion occurs in both slight and severe forms of renal disease.

Cryoscopy.—The freezing-points of urine and blood are altered in renal disease. The index for the urine, indicated by the sign Delta ($\triangle$) is normally 1.3° to 2.3° C. A raised index indicates inadequacy. The normal $\triangle$ index for blood is 0.56° C. This is lowered in renal insufficiency.

Blood urea gives one of the most important indications of renal inadequacy, but varies with diet, fasting, and exercise. Normally 10 to 40 mg. of urea occur in 100 c.c. of blood, and above 44 mg. for 100 c.c. indicates retention and renal insufficiency. In uremia the amount may exceed 200 mg.

Urea-concentration Test (MacLean).—Two hours after the administration of 15 gm. of urea by mouth, the urine should contain 2 per cent. of urea; while with renal insufficiency, the percentage of urea is less than 2 per cent.

Injuries of the Kidney.—Subcutaneous injuries of the kidney result from direct or indirect violence, from crushing, impact of the ribs or from muscular contraction. The kidney may be contused, lacerated, or pulpefied. The peritoneum is rarely torn, except in children. Usually there is rupture of the parenchyma with the formation of a hematoma which may fill the loin and side. Rarely, the pelvis or ureter is torn. A secondary necrosis or abscess may follow, or a peritonitis from extravasation of urine into the peritoneal cavity. The condition is more common in men, and on the right side.

Symptoms.—Injury to the loin or side of the abdomen is followed by the development of an ill-defined, enlarging mass in the loin, with pain, shock, collapse, and later ecchymosis of the lateral abdominal wall or around the external abdominal ring and genitals. Hematuria results from contusion, rupture, congestion, embolism or thrombosis of the kidney, but may be absent when the rupture is superficial, the pelvis not entered, the vessels thrombosed, or the ureter plugged or divided. Large blood-clots in the bladder cause severe vesical spasm and tenesmus. Dysuria, polyuria, retention of urine, anuria, or (rarely) peritonitis may occur.

Prognosis.—Spontaneous recovery is usual. Secondary hydronephrosis, pyonephrosis, or atrophy of the kidney occasionally follows. Death may result from shock, hemorrhage, traumatic nephritis, or secondary peritonitis.

Treatment.—1. Expectant treatment, even though a large hematoma develops, suffices for 90 per cent. of the patients.

2. Operation is required, and should not be delayed with (a) progressive hemorrhage; (b) invasion of the peritoneal cavity, as shown by free peritoneal fluid, abdominal rigidity; (c) urinary extravasation from a wound of the pelvis or ureter. Suture or packing of wound in the kidney, nephrectomy, anastomosis of the ureter, or closure of a peritoneal opening may be necessary. A persistent hematoma should be aspirated, or drained if infected. Clots filling the bladder may require much irrigation or even a cystostomy.

Incised and **penetrating wounds** of the kidney may be followed by external and internal hemorrhage and extravasation of urine, and involve the danger of sepsis and peritonitis. The wounded area should be asepticized, explored, foreign bodies removed, and the kidney sutured, packed, or removed according to the condition found.

Spontaneous perirenal hematoma follows the rupture of blood-vessels of the renal capsule or adjacent tissues. The blood may distend the capsule, or infiltrate the retroperitoneal tissues, diaphragm, and scrotum. The condition usually occurs in elderly men with chronic interstitial nephritis and sclerotic vessels.

Symptoms.—Violent lumbar pain followed by rapidly developing tumor in the loin.

Treatment resembles that for purpura with evacuation or nephrectomy. Palliative treatment is usually fatal.

Movable Kidney (Nephroptosis).—Normally the kidneys, especially the right one, descend and rotate with the descent of the diaphragm. With a thin person, the lower pole of the right kidney can often be felt below the costal margin, especially on deep inspiration. If the entire kidney slips below the costal margin and does not ascend on expiration, a ptosed kidney is present. A kidney that can be carried to different parts of the abdomen is a *floating* or

Fig. 981.—Lateral flexed position used for operations upon the kidney.

wandering kidney. The kidney is normally supported by: (1) The perirenal fat; (2) intra-abdominal pressure; (3) the renal fossa, which is deeper in males and upon the left side; (4) the peritoneal reflection.

Etiology.—(1) Female sex, 90 per cent.; (2) age, thirty to forty years; (3) the right kidney; (4) long narrow trunk with shallow renal fossæ; (5) relaxation of the abdominal walls; (6) enteroptosis (*Glénard's disease*)—with descent of the loaded ascending colon, the nephrocolic ligament tends to drag the right kidney down; (7) tight lacing. Movable kidney is especially common in thin neurotic women. The condition may first be noted after trauma or an unusual strain of the nervous system.

Symptoms.—(1) Those of the underlying neurosis; (2) backache with a sense of dragging, weight, and local tenderness; (3) gastrointestinal symptoms, with ptosed and dilated stomach and constipation; (4) biliary colic and jaundice from pressure or traction upon the biliary ducts (rare); (5) Dietl's crises (Dietl, 1864), recurrent attacks of renal colic due to obstruction by a kink or twist in the ureter, associated with tenderness of the kidney or intermittent hydronephrosis. An associated visceroptosis is common. Except in neurotic patients, symptoms from movable kidney are rare.

Diagnosis is to be made: (1) From enlarged gall-bladder, which is less mobile and does not invade the loin; (2) rarely, an ovarian tumor; (3) retroperitoneal sarcoma or other tumor.

Treatment.—Unless the kidney is producing symptoms, no treatment is required. (1) Treatment of the underlying neurasthenia; (2) measures to improve the general health and nutrition, and to increase the supporting perirenal fat; (3) abdominal support by belt, binder, or strapping with adhesive plaster; a soft pad at times being applied beneath the kidney; (4) nephrorrhapy or partial fixation of the kidney by operation in the neurotic, is rarely of value and at times is harmful, but is to be used when definite symptoms or Dietl's crises are produced and are not relieved by simpler measures. Support, but not

Fig. 982.—Four calculi in the pelvis of the right kidney. (Roentgenogram by Dr. G. C. Bird.)

absolute fixation of the kidney is possible. The sutures should not pass through the renal substance and, as a rule, the kidney should be decapsulated and the supporting sutures introduced through the plicated capsule and the overlying muscle (Edebohls's operation).

Nephrolithiasis.—Renal calculi are formed by the precipitation of urinary salts which, when bound together by colloids, produce a stone insoluble in urine.

Varieties.—A. From *acid urine*, calculi composed of (1) uric acid (75 per cent.), (2) urates of soda and ammonia, (3) oxalate of lime, or rarely (4) cystin and xanthin, or (5) indigo calculi are deposited.

B. From *alkaline urine*, calculi of (1) phosphate or carbonate of lime, or (2) mixed phosphates of ammonia and magnesia are precipitated.

Uric-acid stones are fawn-colored, hard, and smooth. Urate stones are light yellow, soft, and friable: oxalate stones are dark brown or black, hard, rough, or of mulberry shape. Phosphatic stones are whitish, chalky, and soft; carbonate-of-lime stones are white, round, and hard. Cystin stones are yellowish green, smooth, soft, and crystalline. Xanthin stones are of a cinnamon red color, smooth and hard.

In the kidney the stones are rounded, oval, irregular, or dendritic (*coral calculus*). Fine particles are described as sand or gravel. The nucleus of the stone usually consists of urate of ammonia in infants; uric acid in adults; oxalate of lime in persons over forty. The nucleus may contain bacteria, parasites (bilharzia), organic material, or foreign bodies. From one, to several hundred stones may be present.

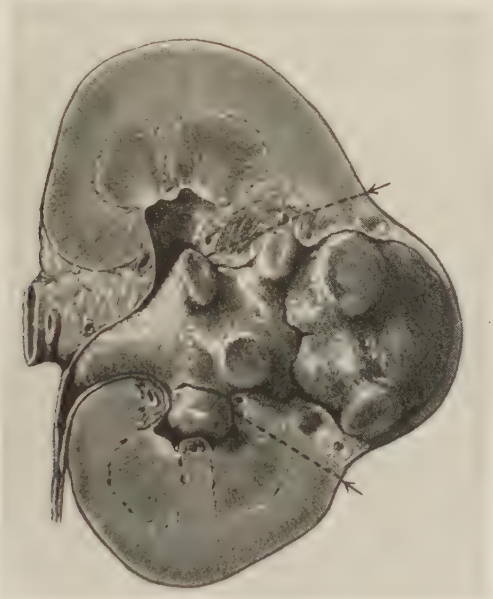


Fig. 983.—Destruction and dilatation of the equatorial portion of the kidney by a large coral calculus. Dotted lines indicate lines of incision for resection and reconstruction of the kidney.

Site.—Calculi are found in the renal pelvis, calices, ureteral orifice, or parenchyma of the kidney.

Etiology.—Stones occur in the kidneys at all ages, but clinically are rare under ten, and common between the age of twenty and fifty. Uric-acid stones are more common, however, before the tenth and after the fortieth year. They are slightly more frequent in males, and an hereditary tendency is at times present with uric-acid stone. The right and left kidneys are equally affected. Favoring factors include a sedentary life, rich nitrogenous diet, lime in the drinking water, hot climate (from the greater concentration of the urine from sweating), hepatic congestion, gout, pernicious anemia, and leukemia. Pyelitis and dilatations of the pelvis and calices favor the formation; a blood-clot from operation or injury may form the nucleus of a stone.

Symptoms.—1. *Latent stone:* A large coral calculus fixed in the substance

of the kidney, or one not producing obstruction, may cause no subjective symptoms. Aching pain or a sense of weight in the loin, and especially pyuria, phosphaturia, microscopic or macroscopic hematuria are often present.

2. *Renal colic* is due to the obstruction to outflow from the renal pelvis. There is acute cutting, agonizing pain referred to the loin and the upper abdominal quadrant, often with nausea, vomiting, chill, or collapse. The lumbar muscles are tense, there is percussion tenderness over the kidney, and the attack is followed by an increase in erythrocytes and leukocytes in the urine. Marked hematuria is unusual. Vesical and lower abdominal symptoms are often absent. The attack usually occurs while the patient is active, lasts a few moments or several hours, and recurs at irregular intervals. The pain may be started by a jolt or jar.

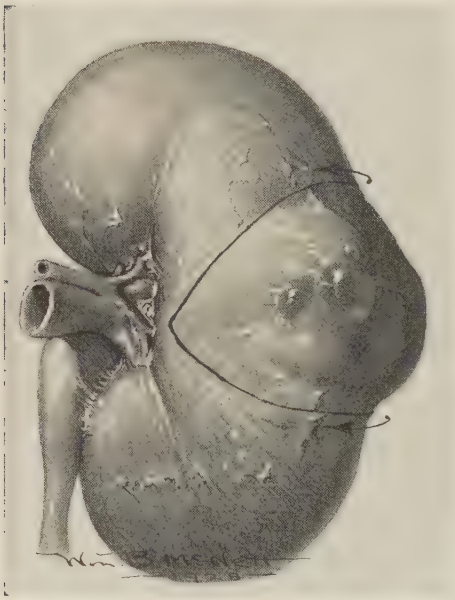


Fig. 984.—Incisions for equatorial resection of the kidney.

Fig. 985.—Resected kidney. Vertical mattress-sutures of fine chromic catgut inserted.

3. *Ureteral Colic.*—If the obstruction is in the upper ureter the symptoms are those of renal colic. If in the mid or lower ureter the pain radiates from the loin to the bladder or external genitals, with urinary frequency or urgency. Tenderness is often present over the course of the ureter, and the symptoms are more persistent from a small impacted stone.

4. *Pyelitis and Pyelonephrosis.*—From stones of long standing with infection, the predominant symptoms are those of a pyelitis or pyelonephrosis.

Diagnosis.—Right-sided ureteral colic has repeatedly been mistaken for appendicitis. With stone the local pain is the first symptom. With appendicitis general tormina and nausea precede the localization of the pain, the attack is of longer duration, the pain less acute, and the urinary and Roentgen findings

for stone are absent. A left-sided renal colic, with nausea and vomiting, is at times mistaken for acute gastritis or gastric ulcer. The attack from the stone, however, is more painful, more abrupt and of shorter duration, is associated with percussion tenderness over the kidney, and followed by urinary changes.

In all cases of doubt roentgenograms should be taken after emptying the intestinal tract. Phleboliths, calcified lymph-nodes, or intestinal contents are differentiated by pyelography or films taken with an opaque ureteral catheter in place. Scratches produced by the stone on a wax-tipped ureteral bougie had a greater diagnostic import before the development of Roentgen technic. Roentgen studies should always be made of both kidneys. Stones are found in the "quiet" kidney in 30 per cent. of the patients.

Prognosis.—Stones produce dilatation and ulceration of the ureter, pelvis, and calices, or destruction of the renal parenchyma. Secondary infection and phosphaturia often persist after removal of stones and, if abnormal cavities remain in the kidney, the re-formation of calculi is to be expected. The results of nephrolithotomy are excellent if done before infection or dilatation of the kidney has occurred.

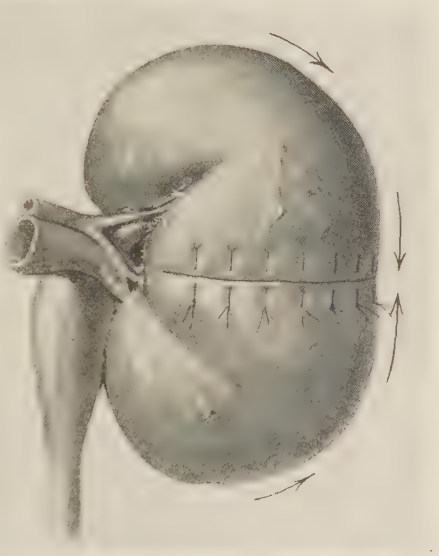


Fig. 986.—Suture of renal parenchyma after resection of kidney, completed.

Treatment.—1. *Palliative Treatment.*—Stones up to 4 mm. in diameter will often pass through the ureter. Morphin, atropin, and hot baths are used to relieve the pain and spasm, demulcent drinks freely given, and occasionally the ureter dilated by catheter, or the stone dislodged by special instruments to facilitate expulsion.

2. *Pyelolithotomy.*—The removal of the stone through a longitudinal incision in the posterior wall of the renal pelvis is usually indicated for stones 5 mm. or more in diameter. This operation may be done without delivery of the kidney through the wound and the opening in the pelvis spontaneously closes without suture. A small cigarette-drain is used for the first forty-eight or seventy-two hours.

3. *Nephrolithotomy* is used in the rare case in which the stone cannot be removed through the pelvis of the kidney. The kidney is incised along Brödel's line to the pelvis, hemorrhage being controlled by compressing the renal pedicle between the fingers. The interior of the kidney is explored by the finger, stones removed, and the wound in the kidney closed by mattress-suture of catgut.

4. *Partial nephrectomy* is used for a partially destroyed or cavitated kidney.

5. *Nephrectomy* is required if the kidney has been disorganized.

With extensive bilateral involvement, nephrostomy or ureterostomy may in rare cases be desirable.

Calculous Anuria.—Etiology.—A calculus may (1) block the urinary flow from the only functional kidney, or (2) block one functional side, and reflexly cause anuria on the opposite side. The stone obstructs the upper ureter, renal pelvis, middle or lower ureter or, rarely, a large calculus of the bladder may be responsible. The condition is more common in males after middle life, who give a previous history of renal colic. Rarely, (3) both kidneys may simultaneously be blocked. Usually one kidney is either absent, atrophic, hydro-

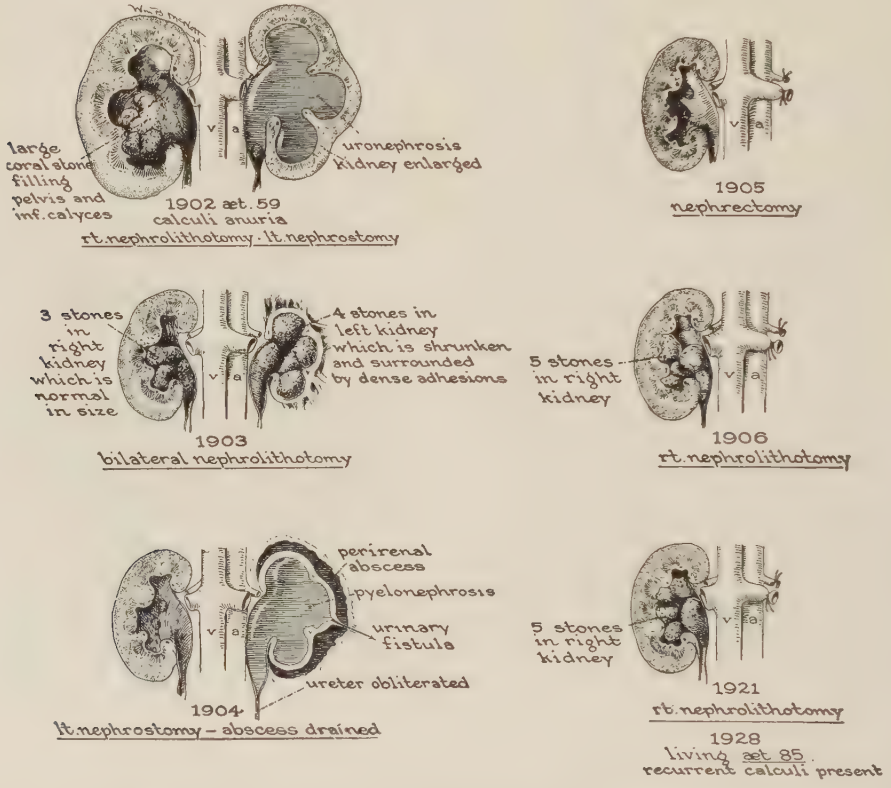


Fig. 987.—Illustrating the tendency for renal calculi to recur when the pelvis or calices are dilated or the seat of infection. Eight operations upon the kidneys in the course of nineteen years. Phosphaturia, pyuria, and decreasing renal function for twenty-six years. In 1903 calculi in the left kidney could be palpated through the thin abdominal wall.

nephrotic or disorganized, as from an impacted calculus, while the other kidney is enlarged, congested, hydronephrotic, or obstructed by a calculus impacted in the pelvis or ureter.

Symptoms.—An acute renal or ureteral colic on the side last affected, usually subsiding within a few days with complete, incomplete, or intermittent anuria. There is constant desire to urinate with depression, insomnia, nausea and vomiting. With hydronephrosis no urine may be passed for from fifteen to twenty-five days, and the distended kidney becomes palpable.

Stages.—(1) Colic; (2) tolerant stage; and (3) uremic stage with profuse, repeated vomiting, constipation, meteorism, sweating, salivation, nausea, epistaxis, edema; a slow, full, irregular pulse; low temperature, contracted pupils, muscular tremors or convulsions, restlessness, drowsiness, and finally coma with slow and irregular respirations.

Prognosis.—Spontaneous recovery occurs in 20 per cent.; early operation is followed by recovery in 50 per cent. of the cases.

Diagnosis should be made from retention of urine, and from anuria due to the pressure of cancer or other pelvic tumor, operative or accidental traumatism, or infection of the lower urinary tract.

Treatment.—Pyelolithotomy, nephrotomy, or nephrolithotomy under local or spinal anesthesia upon the side last involved. A nephrostomy or ureterostomy may be desirable. The patient should be kept warm, protected from cold by woolens, and diaphoresis and intestinal elimination aided.

Hydronephrosis (*uronephrosis*) is a distention and dilatation of the pelvis and calices of the kidney by water or urine, with secondary atrophy of the parenchyma from obstruction to the outflow of urine in the pelvis, ureter, or lower urinary tract. The obstruction may be congenital, or acquired from angulation, kink, valve formation as from adhesions or anomalous artery, stone, new growth, stricture, prostatic enlargement, sustained vesical systole, or traumatism. The condition may be gradual and progressive or intermittent, depending upon the type of obstruction. The fluid consists chiefly of water and sodium chlorid. Sudden complete obstruction to the urinary outflow is followed by arrest of urinary excretion and atrophy of the kidney.

Etiology.—Hydronephrosis is twice as common in women as in men. In the mild forms no mass can be detected; there is pain, occasionally paroxysmal; polyuria, with a continued large flow from the ureteral catheter introduced into the pelvis, differing from the intermittent normal excretion. The condition is best shown by pyelography.

In chronic forms, a lobulated tumor that may contain several gallons of liquid is present, with perhaps little or no pain. Alternating ischuria and polyuria (*"flush-tank" symptom*) may be present.

Diagnosis should exclude renal abscess, pyonephrosis, hydatid cyst of the kidney, ovarian cysts, or ascites.

Treatment.—(1) Nephropexy, if the ureter is kinked by a movable kidney or pressure of an artery; (2) pyelotomy or pyelolithotomy for removal of an obstructing stone; (3) pyeloplasty for the removal of a valvular obstruction in the pelvis of the kidney; (4) ureteral dilatation for stricture; (5) nephrectomy where the parenchyma of the kidney has been destroyed.

Pyelitis.—Infection of the pelvis of the kidney is produced by the colon bacillus (75 per cent.) or other pyogenic micro-organisms. The pelvis is involved by (1) an ascending or urogenous infection, (2) a hematogenous infection, (3) lymphatic infection, (4) direct infection, or (5) infection by contiguity, from adjacent inflamed structures.

Symptoms.—Local pain, tenderness, pollakiuria, dysuria, intermittent or continuous pyuria, fever, chills.

Treatment.—Hot fomentations, alkaline waters, diuretics, balsamics, meth-

enamin, relief from any obstruction to the urinary outflow, irrigation of renal pelvis through a ureteral catheter with weak solutions of silver nitrate or organic silver compounds.

Purulent Nephritis (Pyonephritis).—In suppuration of the kidney the organ may be infected through the blood-stream, the ureter, or from adjacent tissues.

Varieties.—(1) *Circumscribed* renal abscess. (2) *Diffuse*, from an ascending or hematogenous infection with suppurative pyelonephrosis or pyonephrosis. *Pyelonephrosis* usually refers to a suppurative inflammation of renal pelvis and parenchyma. *Pyonephrosis* (pus-kidney) —the pelvis of the kidney is distended by pus and urine. In advanced cases the kidney is converted into a loculated pus-sac, containing pus, urine, cheesy material, and often calculi.

Pathology.—Leukocytic infiltration of the intertubular tissue, with proliferation of epithelium, necrosis, and the formation of single or multiple abscesses. Pyonephrosis usually involves the right kidney.

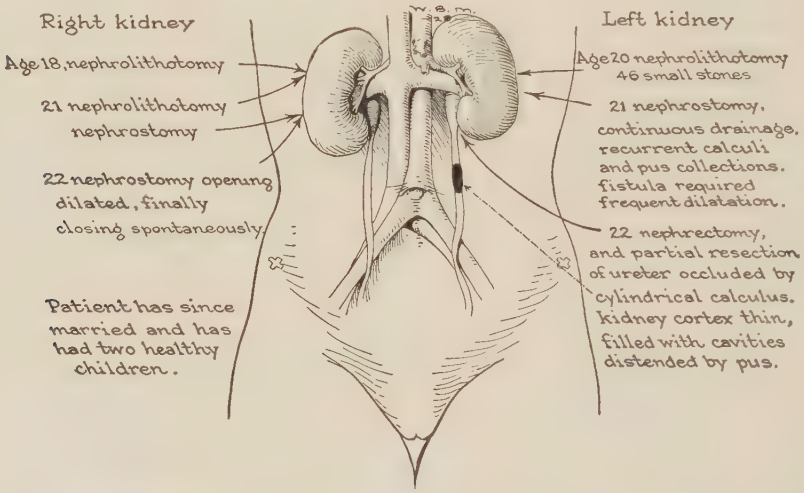

Right kidney
Age 18, nephrolithotomy
21 nephrolithotomy nephrostomy
22 nephrostomy opening dilated, finally closing spontaneously.
Patient has since married and has had two healthy children.
Left kidney
Age 20 nephrolithotomy 46 small stones
21 nephrostomy, continuous drainage, recurrent calculi and pus collections. fistula required frequent dilatation.
22 nephrectomy, and partial resection of ureter occluded by cylindrical calculus. kidney cortex thin, filled with cavities distended by pus.

Fig. 988.—Illustrating the tolerance of the kidney to infection and operative traumatism. Much of this patient's disability and the final loss of the left kidney were due to a small overlooked calculus of the left ureter.

Etiology.—A. *Infection*—as by the Bacillus coli, streptococci, staphylococci, or other pyogenic organism. Either: (1) *Ascending infection* as from cystitis; or (2) *general infection*—as from diphtheria, typhoid, osteomyelitis, septic endocarditis, smallpox, scarlet fever, pyemia, erysipelas.

B. *Obstructive Type.*—As: (1) Obstruction of the ureter from calculus; (2) cancer of the uterus or other pelvic organs; (3) pregnancy, or (4) movable kidney; (5) retention of urine, as from postoperative retention, a large prostate, stone or malignant disease of the urinary tract, or pregnancy; (6) local traumatism, paralysis of bladder after a spinal injury.

Symptoms.—Dull aching pain in the loin and side, with acute exacerbations and septic symptoms, including chills, sweats, fever, vomiting, diarrhea, hectic,

emaciation, prostration. In the acute bilateral form or if the patient has but a single kidney, a typhoid state occurs, with low muttering delirium, coma, and stupor. The kidney is enlarged, tender, usually palpable, and there is overlying muscular rigidity, the urine is scanty and, as a rule, contains pus, blood, pus-casts, but may be clear until the renal pelvis is involved. A purulent cystitis is often associated.

Diagnosis should be made from hydronephrosis, perinephric abscess, a non-purulent pyelonephritis, renal tuberculosis. When both kidneys are infected a cystogram of the bladder should be made to demonstrate a possible regurgitation of the infected urine.

Treatment.—A. *Prophylactic:* (1) Early removal of urinary obstruction; (2) frequent or continuous catheterization, where postoperative urinary retention is feared; (3) slow decompression of the bladder if there is retention with overdistention and back-pressure.

B. *Removal of Cause:* Cystitis should be relieved by treatment; a nephrotomy or pyelotomy should be used for the removal of calculi. Nephrectomy is indicated for extensive unilateral purulent nephritis and multiple abscesses. For bilateral miliary abscesses, decapsulation of both kidneys under spinal or local anesthesia should be tried, with the use of appropriate vaccines. For larger bilateral abscesses, partial nephrectomy, bilateral nephrotomy, pyelotomy, or ureterotomy are useful for drainage, the removal of calculi, or other causal factor.

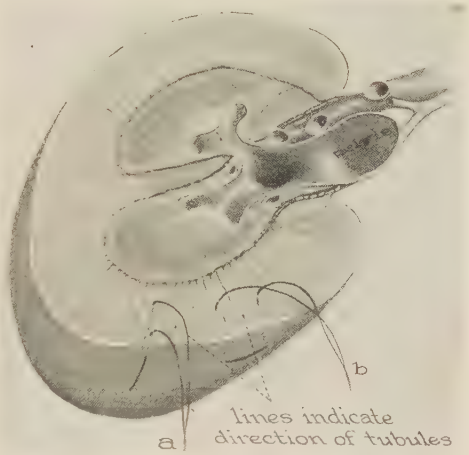


Fig. 989.—Suture of the renal parenchyma. Sutures of fine chromicized catgut introduced for the reconstruction of the kidney. The vertical mattress type of suture indicated at *a* is preferred as causing less constriction of the renal tubules.

Perinephritis (Perinephric Abscess).— Inflammation of the perinephric fat and connective tissue may be: (1) *Primary;* (2) *secondary* to *renal infection*, pyelitis, pyelonephritis, calculus, new growths, or inflammation of lower urinary tract; or (3) *secondary* to *contiguous infection* of appendix, intestines, gall-bladder, rectum, uterus, liver, vertebræ, and pleura.

Pathology.—A large or small abscess usually forms behind the kidney, often with odor from the colon bacillus. The abscess may rupture into the pleura, lung, colon, small intestine, stomach, ureter, peritoneum, or iliopsoas muscle. A sclerosing perinephritis also occurs, with fatty degeneration and the formation of dense fibroconnective tissue.

Symptoms.—Pain, tenderness, muscular rigidity in the loin, rigidity of spine, inclination to the affected side, flexion of thigh, lordosis, pain, constipation, and a temperature of 103° or 104° F. The pain is deep seated, throbbing, radiating at times to the pelvis or knee, and is increased by pressure. Later there is dulness on percussion, fluctuation, redness and edema of the skin of the flank,

elevation of the testis, edema of foot and leg, and occasionally anesthesia or paralysis on the affected side. The urine may rarely contain blood or pus.

Diagnosis is to be made from lumbago, Pott's disease, sacro-iliac disease, psoas abscess, hip-joint disease, appendicitis.

Treatment.—Hot fomentations, tonics, and vaccines, with incision and free drainage as soon as there is evidence of pus formation.

Fig. 990.—Pyonephrosis and pyoureter with tuberculosis of the kidney (Dr. H. A. Duncan).

Renal Tuberculosis.—The tubercle bacilli reach the kidney through the blood, lymphatics, or ureter. The infection may be localized by the diminished resistance of the kidney, caused by retention of urine or traumatism.

Varieties.—1. *Miliary tuberculosis* frequently occurs under the age of ten. The tubercles develop along the blood-vessels, chiefly in the cortex. The process is bilateral, usually is a part of a general miliary tuberculosis, and therefore rarely amenable to operative treatment.

2. *Primary* or *descending caseous tuberculosis* (the infection occurring through the blood-vessels) is a form beginning in the urinary system, although the bacteria may be carried to the kidney from deposits in the mesenteric or peribronchial lymph-nodes, or other focus. This type is usually (90 per cent.) unilateral, and occurs in young women three times as frequently as in men.

The descending type may be: (a) Chronic closed parenchymatous tuberculosis, a hematogenous infection of the kidney without urinary changes. Tuberculous deposits which progress to caseation or liquefaction occur in the cortex or medulla without involvement of the pelvis or ureter. In the slowly progressing chronic forms a marked intertubular sclerosis is associated. (b) Mixed parenchymatous and pelvic tuberculosis. The infection involves the lining of the pelvis and calices as well as the medulla of the kidney. The process may follow rupture of closed caseous abscesses of the pyramids into the pelvis. Tubercles are deposited in the mucosa of the pelvis and ureter, with secondary fusion, caseation, and ulceration. The urine from the infected kidney contains pus,

blood, and tubercle bacilli. Secondary sinuses may extend to the surface of the body, and the kidney be converted into a small adherent fibrous or caseous mass.

3. *Secondary* or *ascending type* represents an extension from a pre-existing tuberculosis of the vesicles, epididymis, prostate, bladder or other part of the urinary tract. This type is more common in men, is unilateral in only 50 per cent. of the cases and is, of course, less amenable to treatment.

Symptoms.—(1) *Irritability of the bladder* with urgency, polyuria, and pollakiuria especially at night and, at times, a dysuria with pain in the neck of the bladder. Later, renal or ureteral colic may occur. (2) *Hematuria*, profuse and without apparent cause, is often the initial symptom. (3) *Symptoms referred to the kidney* may be slight or absent. Lumbar pain may be absent or variable, dependent upon the obstruction to the flow of urine. (4) *Tenderness on fist-percussion* over the loin is usually present, with increased tension of the muscles. In the later stages the enlarged kidney or a perinephritic mass may be felt. (5) *General symptoms*—evening temperature 100° or 101° F., with loss of flesh, and with anemia, rigors, sweats. (6) *Acid, apparently sterile pyuria*, hematuria and polyuria with diminution of urea and phosphates. Cystoscopy shows the ureteral orifice red, swollen, pouting, or retracted ("*golf-hole type*"), and often adjacent tuberculous ulcers of the bladder. (7) Functional tests reveal a delayed and *diminished dye elimination.*

Roentgen Findings.—Opacities and calcareous deposits in the substance of the kidney. Pyelogram may show obliteration or moth-eaten margins of the calices, irregular dilatation of the pelvis, strictures and irregular dilations of the ureter.

Complications.—1. *Tuberculous Perinephritis.*—A dense mass of very adherent fibroconnective tissue may form about the pelvis, and caseation, liquefaction, and the formation of a tuberculous perinephritic abscess occur.

2. *Ureteral Tuberculosis.*—The ureter usually becomes greatly thickened, irregularly dilated and constricted, with marked infiltration of the walls, ulceration of the lining mucous membrane, and traction on the bladder.

3. *Hydro-* or *pyo-nephrosis* follows obstruction of ureter or renal pelvis.

4. *Mixed infection* by the colon bacillus or other pyogenic micro-organism is a common and serious complication.

5. *Secondary infection* of other portions of the genito-urinary tract, including the opposite kidney.

With mixed or advanced infection the patient emaciates, becomes pale and cachectic, there is hectic temperature, and often a large tender and, at times, fluctuating mass in the region of the kidney; the urine containing much pus. While the ureter is blocked the urine becomes clear, in association with renal colic and enlarging kidney. The rigid, thickened ureter may be felt through the rectum, vagina, or the emaciated abdominal wall.

Diagnosis.—An apparently causeless (1) irritability of the bladder, (2) cystitis, (3) hematuria, or (4) "sterile" pyuria suggests tuberculosis of the kidney. Tubercle bacilli may be found in the smear from the urinary deposit, or more surely by guinea-pig inoculations. Tuberculosis of the lungs or other organs may be detected. The seminal vesicles, epididymis, and bladder should always be examined.

Prognosis is unfavorable in the miliary form and usually in the ascending type, although patients with secondary renal tuberculosis often live for years. Death occurs from uremia, sepsis, and generalized tuberculosis. In primary unilateral disease, 60 per cent. of the patients are permanently relieved by nephrectomy or nephro-ureterectomy. Recovery may follow the decapsulation of a residual kidney with miliary tuberculosis. Occasionally a spontaneous arrest occurs.

Treatment.—1. *Primary unilateral tuberculosis* of the kidney should be treated by nephrectomy, or nephro-ureterectomy, if the ureter is diseased. Partial nephrectomy is usually followed by recurrence and is rarely advisable.

Fig. 991.—Large cyst of upper pole of kidney.

2. *Secondary unilateral tuberculosis* in patients with good general resistance is usually best treated by nephro-ureterectomy or nephrectomy. Tuberculous ulcers in the bladder often heal after removal of the infected kidney. Advanced lesions in the lungs or other organs, however, contraindicate the operation.

3. *Primary bilateral tuberculosis* in the early stage may be treated by rest, diet, heliotherapy, and tuberculin. For resistant disease of a mild type, decapsulation of the kidney may be considered. In bilateral tuberculosis with slight involvement of one side and disorganization of the other kidney, removal of the badly diseased organ is at times desirable.

4. *Secondary bilateral tuberculosis* usually contraindicates operation. Neph-

rotomy, nephrostomy, and ureterostomy are frequently followed by a mixed infection and a persistent tuberculous fistula, and can be considered only as rare palliative measures, to be employed when the patient's life is threatened through obstruction to the urinary flow.

Tuberculous perinephritic abscess should be evacuated or the walls excised, without drainage, unless there already is a mixed infection.

Polycystic Kidney.—A progressive bilateral, often enormous enlargement of the kidneys, which are converted into a mass of large and small thin-walled cysts containing clear amber or brownish liquid.

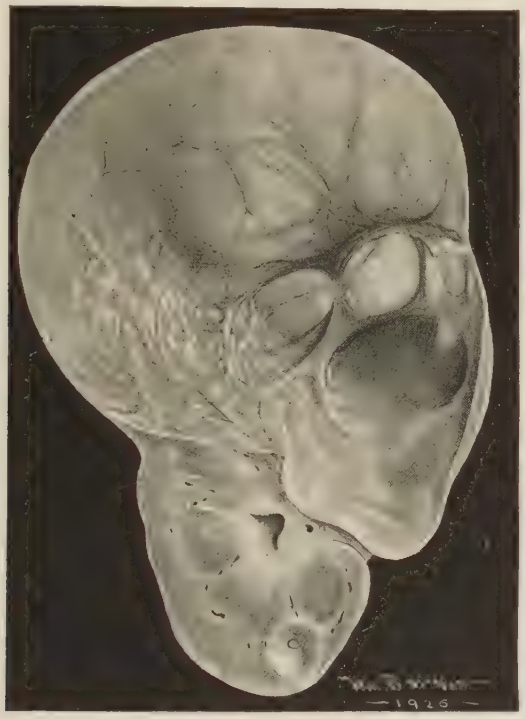


Fig. 992.—Cystic disease of kidney.

Etiology.—Polycystic kidney is more common in males, and may be congenital or develop between the ages of twenty and eighty years. The enlargement is often first noticed on one side, but is soon followed by that of the other kidney. The kidney may weigh from $\frac{1}{2}$ to 8 kilos and consist almost entirely of cysts, with little evidence of the normal parenchyma. Cystic disease of the liver and spleen often is associated.

Symptoms.—Irregular, lobulated, bilateral renal enlargement, with polyuria or ischuria. The urine is pale and watery. Anemia and uremia gradually develop in from one to twelve years. An acute type develops in adults, with chill and fever, involving first one and then the other kidney.

Treatment.—As the condition is almost invariably bilateral with great diminution of the function of the kidneys, nephrectomy is contraindicated.

The progress of the disease may be retarded by decapsulation, incision, and evacuation of cysts under local or spinal anesthesia.

Aneurysm of renal artery varies in diameter from 0.5 to 25 cm., usually involves a branch of the renal artery, and constitutes less than 2 per cent. of all aneurysms. Middle-aged men are chiefly affected, especially after traumatism. A mass with pain, throbbing, pulsation, and hematuria may be present, and death may occur early from rupture into the peritoneum, renal pelvis, or adjacent tissues. The calcified walls may simulate a renal calculus on the roentgenogram.

Prognosis.—Progressive enlargement and death from rupture are usual without operation. All patients treated conservatively die. Operation is often difficult and dangerous from adhesions and hemorrhage.

Treatment.—Ligation and excision. Nephrectomy is usually necessary.

Fig. 993.—Acute right polycystic kidney which rapidly developed after a pelvic operation on a middle-aged woman; the left kidney being of normal size and contour. One week after the right nephrectomy cystic disease developed in the left kidney. Left decapsulation and evacuation of cysts. Patient living five years after the operations.

Tumors of the Kidney.—Benign tumors (including fibroma, angioma, papilloma, adenoma) are rare. Sarcomas usually appear in childhood. Hypernephromas and other tumors, after middle life.

Varieties.—Hypernephroma, 70 per cent.; carcinoma, 7 per cent.; sarcoma and other tumors, 23 per cent.

1. The tumors of early childhood usually remain localized, grow rapidly, and are highly malignant.

2. Hypernephroma develops in adults, grows slowly with a marked tendency to metastasize.

3. Tumors of the renal pelvis are similar to the tumors of the urinary blad-

der, vary greatly in malignancy, and have a marked tendency toward implantation along the course of the ureter.

Sarcomas are common in children under five years of age, forming enormous globular tumors that may fill the abdomen. They often are cystic from hemorrhage and degeneration. Sarcomas are encapsulated, not infiltrating, but invade the vena cava, ureter, and lymph-glands, and recurrence or metastasis is usual after nephrectomy.

Myxosarcoma occurs in infants and also, but rarely, in adults.

Diagnosis is made by finding a rapidly growing tumor developing from the loin in childhood. Hematuria and other urinary changes are often absent. A pyelogram is valuable.

Prognosis unfavorable.

Treatment.—Early nephrectomy and Roentgen treatment may prolong life for several years, but rarely prevents recurrence.

Hypernephroma (*adrenal* or *Grawitz's tumor*), formerly thought to arise from aberrant embryonic adrenal tissue or "rests" in the kidney, develops as globular, rapidly growing, well-differentiated, fairly encapsulated, golden brown mass within the renal capsule. It usually grows in the upper pole, and has a tubular structure resembling the adrenal cortex. It also, but rarely, develops in the ovary, testis, or uterus.

Etiology.—Middle life, male sex.

Symptoms.—Increasing intermittent hematuria, enlargement of the kidney, evening fever, gradual wasting and increasing weakness, anemia, and occasionally pigmentation of the skin.

Diagnosis.—Progressive loss of weight, increasing weakness and anemia, and afternoon fever, without other cause in a person of middle age, should arouse the suspicion of hypernephroma. Unless the tumor involves the pelvis, no urinary changes may be present in the early months of the disease, and the growth may acquire considerable size before it becomes palpable. The diagnosis is aided by pyelography, and especially by an exploratory abdominal incision.

Prognosis.—Unfavorable. Metastasis is almost invariable to the lungs through the veins, or to the liver and bones, especially the skull, humerus and femur, the patient dying within three years despite treatment.

Treatment.—Early complete nephrectomy. A lumbar retroperitoneal excision is used for smaller growths. A transperitoneal abdominal nephrectomy for large tumors.

Carcinoma of the Kidney.—Usually occurs on the right side, and gives metastasis to lungs and liver.

Etiology.—Males, chiefly between fifty to sixty-five years of age.

Symptoms.—Hematuria, tumor, pain often slight or absent, except with an infiltrating carcinoma, polyuria, varicocele, anemia, emaciation, cachexia. Hematuria is slight or absent in sarcoma, profuse in 70 per cent. of carcinomata and hypernephromata.

Pyelography.—(1) Displacement of kidney and ureter especially toward the median line; (2) filling defect in the pelvis with obliteration or distortion of one or more calices; (3) dilatation of pelvis or hydronephrosis.

Treatment.—Early nephrectomy.

Tumors of renal pelvis include papilloma and epithelioma.

Symptoms.—Hematuria, usually marked, recurrent, and even fatal. The tumor may obstruct the renal pelvis or ureter with secondary hydro- or hematonephrosis. Pain is unusual, except as colic from passage of clots or tumor fragments. The tumor varies in size from a few millimeters to many centimeters in diameter.

Papillary epithelioma of the renal pelvis produces violent hematuria, but is less prone to metastasize than other forms of carcinoma, which spread to lungs and liver.

Diagnosis is made by finding tumor fragments or villous masses in the urine, and by pyelography.

Prognosis favorable after early nephrectomy.

Treatment.—Nephrectomy or nephro-ureterectomy.

Operations upon the Kidney.—Delivery of the kidney through the lumbar wound should be made with great care. In a number of instances, avulsion of the kidney and death from hemorrhage has occurred in the delivery of the organ.

Decapsulation of the kidney is of limited value for congestion, inflammation, and degeneration of the kidneys. It has been used in acute suppression or anuria, in mercurial poisoning, and in nephritis, to release the kidney from pressure and to supply a new anastomotic circulation through the cortex of the kidney. In a few cases, a decided but usually temporary improvement has followed. As a rule, the operation should be done under local or spinal anesthesia.

1. **Nephropexy (Edebohls' Operation).**—The kidney is exposed, the fatty capsule stripped off and placed below the kidney. The true capsule is rolled back and well anchored to the overlying muscles by interrupted sutures of chromic catgut or silk. It is wise to leave the upper pole free to oscillate with the movements of the diaphragm. Supporting sutures should not be placed in the fragile cortex of the kidney.

Operations to produce adhesions between kidney and adjacent tissues by gauze packing usually fail to give continued support.

2. **Nephrotomy (Incision of the Kidney).**—The incision is made along the convex border just behind the mesial plane, where the ventral and dorsal vessels meet (*Brödel's line*). A finger may be introduced to explore the pelvis, and the wound later closed by mattress-sutures. Hemorrhage is more marked, and damage to the kidney more severe than in pyelotomy which, if possible, should always be substituted. Violent recurrent, or even fatal secondary hemorrhage occasionally follows nephrotomy.

3. **Needling** the kidney to locate stone is uncertain, and is now rarely used.

4. **Nephrolithotomy.**—By a nephrotomy, stones are located by finger or instrument, and removed.

5. **Pyelotomy (incision of pelvis of the kidney)** is made with or without delivery of the kidney through the wound. The ureter may first be located and traced to the pelvis.

6. **Pyelolithotomy (a pyelotomy when a stone is removed).**—The posterior wall of the pelvis is freed from fat and adjacent tissue, and opened by an incision in the axis of the ureter. Closure of the opening is usually unnecessary, spontaneous healing usually occurring without the formation of a secondary urinary fistula. A small tube or cigarette-drain should be used for the first forty-eight to seventy-two hours.

7. **Nephrostomy (drainage of the pelvis of the kidney)** by a tube introduced through parenchyma involves the danger of secondary infection, and should rarely be used.

8. **Pyelostomy (ureterostomy or uretero-enterostomy)**, employed where there is obstruction below the kidney, or where it is desired to put the bladder at rest, the urine being conducted into a reservoir or bag attached to the patient's body, or the intestine.

9. **Nephrectomy** necessitates the presence of a second kidney of fair functional capacity. If there is any doubt (horseshoe, pelvic, or fused kidney) the other kidney should first be examined by the hand introduced through an incision in the peritoneum.

Partial nephrectomy, polar or median, is entirely feasible.

URETER

Injuries of Ureter.—*Subcutaneous contusion*, laceration or rupture of the ureter follow violent abdominal or pelvic injury from blows, kicks, falls, and crushes. The injury is usually extraperitoneal with secondary urinary extravasation, inflammation and often suppuration, but intraperitoneal leakage with secondary peritonitis, or ureteral obstruction with secondary nephrectasis may occur.

Symptoms.—Pain, enlarging mass in the loin, suppression or reduction in the amount of urine from the bladder, and at times hematuria. Secondary symptoms are due to inflammation, suppuration, or peritonitis.

Prognosis.—Small openings into the ureter or renal pelvis usually close spontaneously or after drainage. Division of the ureter is followed by urinary extravasation and, after drainage, a persistent urinary fistula. Continued leakage of urine into the peritoneal cavity usually causes a fatal peritonitis.

Treatment.—If there is evidence of peritoneal irritation or extravasation shown by abdominal rigidity and shifting dependent dulness, an immediate abdominal exploration and repair is necessary. If a lumbar extravasation of urine occurs, lumbar incision with drainage is indicated, the ureter being sutured or anastomosed if possible. Nephrectomy is used where secondary degeneration of the kidney has occurred, or for a persistent urinary fistula that cannot be controlled by suture or anastomosis.

Injury to ureter during operation occurs especially during operations that invade the base of the broad ligaments, as hysterectomy or in ovariotomy when the ureter is displaced. The ureter may be accidentally ligated, lacerated, clamped or divided, with secondary nephrectasis, anuria, urinary extravasation, suppuration, or peritonitis. In the operation for carcinoma of the uterus, the ureter may be so denuded of its blood-supply as to undergo secondary necrosis.

Diagnosis is made during the operation by locating and tracing the ureter. The ureter may be recognized by the characteristic sliding (*trombone*) peristaltic waves that are increased by mechanical irritation. After operation, absence of urinary flow from one ureter and an obstruction to the passage of the ureteral catheter are significant.

Treatment.—Prompt ureterorrhaphy, uretero-ureteral anastomosis to the same or opposite ureter, ureterocystostomy, ureterocolostomy, or sigmoidoscopy, ureterostomy with external fistula, or nephrectomy.

Ureteral Stricture (Obstruction).—(1) *Congenital stricture* usually is found close to the renal pelvis; (2) *kinking* often occurs over an accessory renal artery, or from traction or pressure produced by a tumor or following operation or injury; (3) *impaction* of calculus; (4) *acquired stricture* from ureteritis, ureteral ulceration or malignant invasion; (5) a high oblique junction of the ureter to the dilated renal pelvis with *valvular stricture*. This form of obstruction is more common in women between the ages of thirty and forty, and in the right ureter. The kidney and the ureter above an obstruction are dilated.

Symptoms.—Ureteral or renal colic; pus, blood, and ureteral epithelia in the urine. Pollakiuria, incontinence, and dysuria. The stricture may be located by the ureteral catheter and ureterography and, at times, by an abdominal or by bimanual vaginal examination.

Treatment.—(1) Graduated dilatation by ureteral catheters; (2) plastic operation upon the renal pelvis and ureter, as after the plan of a Finney pyloroplasty; (3) the anastomotic operations used for injury to the ureter; (4) nephro-ureterectomy or nephrectomy.

Ureteral calculus causes *ureteral colic*, hematuria, anuria, urinary crystals, blood, pus, excess of ureteral epithelial cells, and a shadow on the roentgenogram.

Diagnosis should be made from an encysted vesical calculus, cystitis, ureteritis, vesical tuberculosis, or a prolapsed inflamed ovary. If the obstruction is complete and persistent, the kidney atrophies, but the kidney may again function if the obstruction is relieved within eighteen months. Hydronephrosis follows incomplete or intermittent obstruction, pyonephrosis if there is infection. The ureter above the obstruction is thin or thick, and dilated. If the other kidney is affected, reflex anuria and death may occur.

Fig. 994.—Calculus of the upper right ureter. Recurrent attacks of pain with nausea and vomiting had for four years been ascribed to gastric ulcer.

Treatment.—Opiates, relaxants, hot baths, diuretics are used during the attack. A ureteral calculus up to 4 mm. in diameter will probably pass. The passage may be aided by dilating the lower ureter with catheters or ureteral sounds, or by using extractors. If large and impacted near the kidney, the stone should be removed through a lumbar incision by pyelotomy or ureterotomy, if at brim of the pelvis by a McBurney incision and extraperitoneal exposure by stripping the peritoneum and attached ureter to the midline. The pelvic ureter can be exposed by one of the lower abdominal incisions, a parasacral incision, or one through the vaginal vault. If the stone is in the wall of the bladder, it may be reached through an operating cystoscope by a suprapubic or vaginal cystostomy.

Operations on the Ureter.—1. **Ureterotomy** is used for exploration of the ureter and for the extraction of calculi (*ureterolithotomy*).

2. **Ureteropyelostomy.**—An anastomosis between the ureter and pelvis of the kidney is used to overcome obstruction.

3. **Ureteral anastomosis** may be end-to-end or lateral. Non-absorbable sutures may form the nuclei of secondary calculi, and should not be used. The suture may be made over a catheter brought out through the bladder or kidney and left in place until union has occurred.

Lateral Uretero-ureterostomy (van Hook's Operation).—The end of the lower segment of the ureter is ligated and a vertical opening made below the ligature, into which the lower end of the upper segment is drawn by catgut sutures, the end of the upper segment being split in a longitudinal direction to prevent stenosis.

Ureterocystostomy and *uretero-enterostomy* are forms of anastomosis used when uretero-ureterostomy is not feasible.

4. **Ureterostomy.**—A direct external drainage of the ureter, usually through the loin, is at times desirable.

5. **Ureterocolostomy** (Coffey).—The ureter is divided, the distal end ligated, and a catheter introduced for 10 cm. is firmly tied into the proximal end, carried through the wall of the colon, and brought out through the anus by the aid of a suture attaching the catheter to an introduced rectal tube. By incision and suture the ureter is buried between the submucosa and mus-

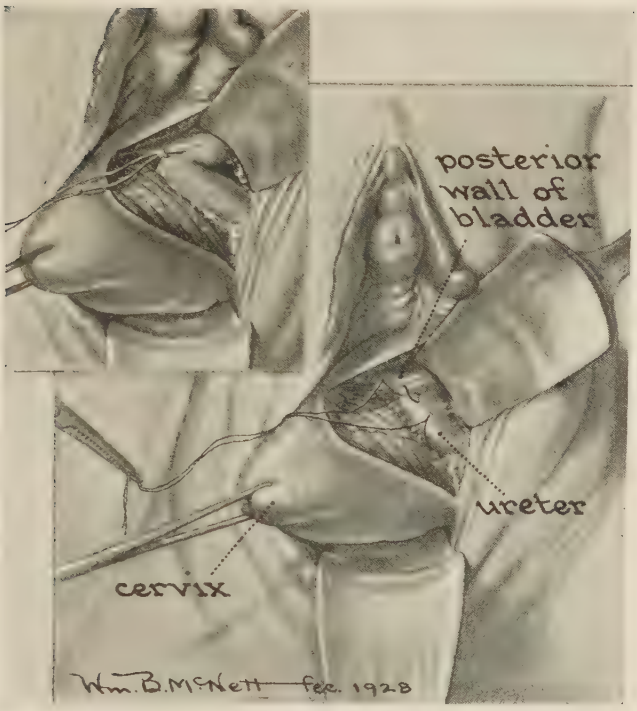


Fig. 995.—Vaginal ureterocystostomy by ligature: Dilated ureter exposed through a vaginal incision and fastened by a through-and-through silk ligature to the posterior wall of the bladder. Insert: Ligature tightly tied.

Fig. 996.—Vaginal ureterocystostomy: The ends of the ligature are withdrawn through the bladder and urethra by a probe.

cularis of the colon, for a distance of about 4 cm. Through sloughing the catheter comes away spontaneously in about one week.

6. **Partial** or **complete ureterectomy** is used in tuberculosis or malignant disease, usually in association with a nephrectomy.

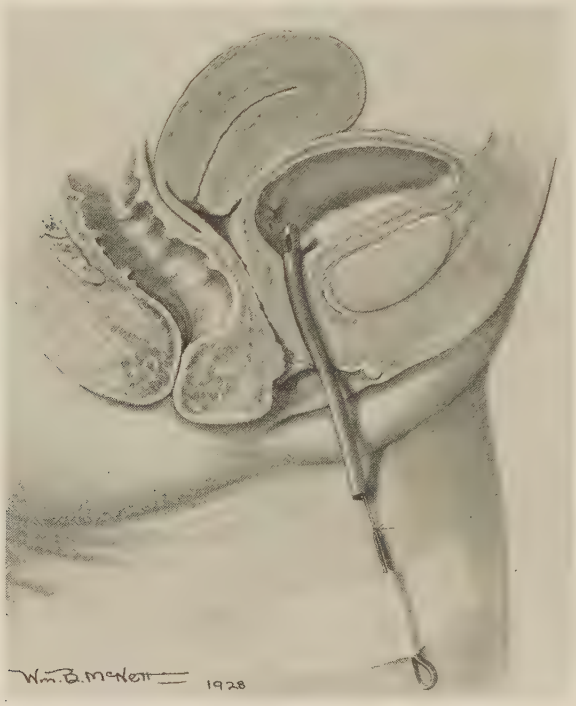


Fig. 997.—Ureterocystostomy: Traction by an attached rubber band causes the ligature to cut its way through the wall of the ureter and bladder, completing the anastomosis. The urethra is protected from pressure by a soft-rubber catheter.

GENERAL FUNCTIONAL DISORDERS

Retention of Urine.—Etiology.—(1) *Penis.* From mechanical obstruction by rings, bands, phimosis, or new-growths. (2) *Urethra.* From stricture, foreign bodies, calculi, rupture, hypertrophy. (3) *Prostate.* From inflammation, abscess, hypertrophy, or new-growth. (4) *Bladder.* From stone or new-growth of the neck. Spasm or congestion of sphincter muscles, especially after operations upon the rectum or genitals, pressure of adjacent tumors, by inflammatory masses, uterine fibroids, pelvic abscess, vaginal packing, or a retroverted pregnant uterus. (5) *Paralysis* from disease or injury of the brain or spinal cord. (6) *Hysterical palsy.* (7) *Atony of the bladder* from overdistention, cystitis, senility.

Diagnosis.—An oval hypogastric swelling with pain, except in paralytic forms, is followed by the overflow of distention and rarely rupture of the bladder or urethra. The bladder wall is dilated and thin, but in chronic cases may become thick and hypertrophied. Sacculation of the bladder, secondary hydronephrosis, pyelonephrosis, or pyelonephritis may follow.

Diagnosis is to be made from suppression of urine, calculous anuria, and ruptured bladder.

Treatment.—Catheterization or aspiration of the bladder. Removal of the underlying cause.

1. *For Congestion and Spasm:* Hot compresses, hot sitz-baths, sitting or standing posture, subcutaneous injection of pituitrin, ergot, morphin, belladonna, or atropin.

2. *Obstructive Type:* Removal of obstruction. For prostatic enlargement or urethral stricture, the urethra is fully distended by warm sterile olive oil. Without permitting the oil to escape, a woven coude or bicoude catheter is passed, the tip pointing anteriorly. In prostatic obstruction this method will usually succeed, when prostatic metal catheters and soft-rubber catheters fail. In *stricture of the urethra*—dilation under anesthesia, beginning with the largest

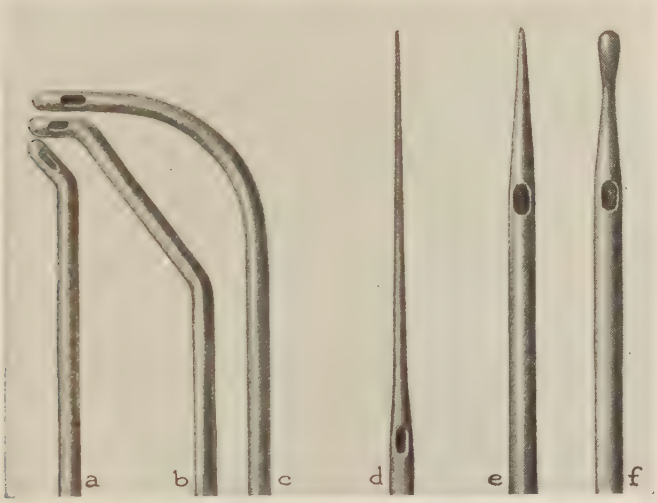


Fig. 998.—Types of catheters: *a*, Coude, or single elbowed catheter; *b*, bicoude, or double elbowed catheter; *c*, prostatic curve; *d*, rat-tail catheter; *e*, conical tip; *f*, bulbous tip.

size bougie that can be introduced. If a catheter cannot be introduced, filiform bougies should be tried or a suprapubic aspiration used. To avoid the peritoneum, the cannula should be introduced in the midline close to the pubis. If a trocar is used, a catheter can be passed through the cannula and left in the bladder after withdrawing the cannula. *Suprapubic cystostomy* often is indicated if there is vesical tumor or marked prostatic hypertrophy.

Perineal urethrotomy and cystostomy for an impassable urethral stricture.

3. *Paralytic Distention:* Reflex emptying of the bladder should be established by stroking the thighs, or by dilating the sphincter at regular intervals. Catheterization should be avoided, as a dangerous cystitis usually follows.

Incontinence of Urine.—**Nocturnal incontinence** (*enuresis*) occurs chiefly between the ages of two and fourteen, from reflex stimulation of an abnormally excitable vesical center by vesical distention, intestinal or rectal parasites, polyps, phimosis, gravel or emotion. It may follow or be relieved by emotional

influence, as accident or operation. It usually disappears at puberty. In adults it may indicate epilepsy.

Treatment.—Suggestion, tonics, out-of-door life, hard bed, light covering, and the patient taught to sleep upon his side or abdomen by a towel fastened around the waist with a knot over the spine. Removal of peripheral irritation, from acid urine, uric-acid crystals, tight or adherent prepuce, rectal irritation from worms or other cause, enlarged tonsils. Rarely dilatation of the posterior urethra, and the application of nitrate of silver give relief.

Passive incontinence is characterized by defective sphincter-control from: (1) *Paralysis* of the sphincter as from injury or disease of the spinal cord; (2) *mechanical influences*—relaxed or overstretched urethra, especially in women after childbirth, or distention of the sphincter by stone or new-growth.

Treatment is that of the underlying condition.

Stammering bladder (Paget) is characterized by spasm of the urethral muscles, difficulty in starting the flow, and spasmodic arrest during urination. The condition is to be treated by the passage of large urethral sounds.

In locomotor ataxia there may be vesical spasm, difficulty or irregularity in urinating, retention, or anesthesia with unconscious urination.

False incontinence (*incontinence of overflow*, *ischuria paradoxa*) occurs with retention of urine, great distention of the bladder; the intravesicular pressure overcoming the sphincter, leading to dribbling. A common, serious, and frequently overlooked condition.

Etiology.—(1) Postoperative retention; (2) obstruction to the outflow of urine from stricture, enlarged prostate, neoplasm; (3) paraplegia from disease or injury of the spinal cord.

Danger.—The sudden emptying of the overdistended bladder may be followed by acute hemorrhagic or necrotic cystitis, a congestive or septic nephritis, with anuria.

Diagnosis.—The frequent passage of small quantities of urine should always suggest a distended bladder. The large ovoid distended bladder may be mistaken for the pregnant uterus, an ovarian tumor, or even an abscess.

Treatment.—Gradual decompression of the bladder by: (1) Introduction of an indwelling catheter, 120 c.c. of urine being withdrawn every two hours until the bladder has been emptied; (2) introduction of indwelling catheter, the outlet of which is placed 40 cm. above the level of the pelvis, so that the bladder gradually empties under pressure. The outlet is lowered 3 cm. every two hours until the bladder is empty.

BLADDER

Congenital Anomalies.—Defects in the development of the allantois are responsible for umbilical urinary fistula and ectopia vesicæ.

Ectopia Vesicæ (Exstrophy of the Bladder, Extroversion of the Bladder).—A defective embryonic closure of the lower urinary system, including the lower anterior abdominal wall, symphysis, bladder, urethra, and external genitals. The posterior wall of bladder protrudes as a red mass through an opening in the anterior abdominal wall. The external genitals are rudimentary, the urethra is represented by a shallow groove (*epispadias*). The pelvis is flat and rudi-

mentary with separated pubic bones, the umbilicus is obscured. The protruding mucous membrane of the bladder becomes irritated and inflamed and urine continuously dribbles from the patient, with secondary excoriation of the skin and often pyelonephritis.

TREATMENT.—1. *Fitting of a vulcanite* or *soft-rubber urinal.* Leakage and odor render urinals unsatisfactory.

2. *Extraperitoneal transplantation* of an island of the bladder containing the urethral orifices into the rectum (*Maydl's operation*).

3. The ellipse of *bladder wall* containing the ureters is *implanted in the sigmoid.*

4. *Extraperitoneal transplantation of each ureter* into the lateral rectal wall, with a small island of adjacent rectal mucosa (*Peters' operation*). Catheters which protrude from the anus are left in the ureters for several days after the

Fig. 999.—Exstrophy of the bladder and epispadius twelve years after transplantation of the ureters into the rectum (Maydl's operation). There is no leakage, and urine is voided from the rectum about three times a day. A secondary cystectomy has been deferred by the patient.

operation or a rectal tube used to prevent tension on the line of suture. The residual vesical wall may be excised and the cavity packed. In *Coffey's modification*, the cut end of the ureter is buried in a tunnel between the muscular and mucous coats of the bowel for 3 or 4 cm., before entering the intestinal lumen. After ureteral intestinal anastomosis there is first a watery diarrhea, but the rectum soon acquires a tolerance for the urine so that the movements occur only every three to five hours.

A secondary ascending infection with pyelonephrosis not infrequently follows the earlier types of operation from contraction of the new ureteral orifice. The patient should be at least three years of age before an operation is attempted.

5. *Anastomosis of the ureters* into the isolated cecum (*Makka's operation*) with appendicostomy, the urine being evacuated by a catheter through an ap-

pendicostomy opening. In patients over forty, a bilateral lumbar or inguinal ureterostomy and the wearing of a fitted conducting apparatus or special urinal is a safer procedure, but leaves annoying fistulæ.

6. *Osteoplastic reconstruction* of the bladder. The pubic bones are united anteriorly by dividing the sacro-iliac synchondrosis (Trendelenburg), or by dividing the pubic rami (Perkins, Schlange). Plastic closure of the anterior abdominal defect and urethra is then made. The operation is dangerous and, after the closure of the bladder, the small size of the organ, incontinence of urine, persistent cystitis, growth of hairs from inturned skin, formation of recurrent calculi in the bladder, and secondary ascending infection give much trouble. These operations, however, may render it easier to adjust a urinal.

As a rule, implantation of the ureters into the rectum, followed later by excision of the bladder with plastic reconstruction of the external genitals, is the preferred operation.

Diverticula of the Bladder.—Varieties: (1) False diverticula are shallow pouches from the herniation of the mucosa in a trabeculated bladder. (2) True diverticula are accessory pouches communicating with the bladder by small orifice, rarely congenital, but usually developing in men over forty years of age.

In the diverticulum, retention, decomposition of urine, pus formation, and phosphaturia occur with a tendency to calculus formation.

Symptoms.—Cystitis with the intermittent passage of purulent urine, frequent and difficult urination.

Diagnosis is made by the cystoscope or by the roentgenogram, after filling the bladder with a 10 per cent. solution of sodium bromid.

Congenital diverticulum is found in young males without pre-existing urethral obstruction, with a single pouch near the ureteral orifice, from a few millimeters to 30 or more centimeters in diameter. The diverticulum may be larger than the bladder. The walls are without muscle, and may compress the adjacent ureter and cause uronephrosis.

Symptoms.—Sluggish, retarded, urinary flow, difficulty in emptying the bladder, the passage of clear and then turbid urine. The sac may be felt by bimanual examination, and may enter a hernial canal. The diagnosis is made by cystoscopy and roentgenograms.

Treatment.—Extraperitoneal excision. A ureteral catheter is passed to prevent injury of the ureter, the diverticulum packed firmly with gauze, the peritoneum stripped from the bladder and diverticulum, the sac excised and the opening in the bladder closed by tier sutures of catgut. In the after-treatment an indwelling catheter or suprapubic drain is used (*Bransford-Lewis method*).

Rupture of the Bladder.—Etiology: (1) Fracture of the pelvis; (2) blows and pressure over the distended bladder; (3) adult males are chiefly affected; (4) rupture from unrelieved retention.

The rupture may be *intraperitoneal* or *extraperitoneal.*

A. Intraperitoneal rupture involves the superior surface or dome of the bladder, where there are the fewest muscular fibers. There is acute abdominal pain, rigidity of the abdominal wall, evidence of free fluid in the abdominal cavity, and secondary peritonitis. Either no urine, or small quantities of blood-stained urine are passed.

Diagnosis.—Hydrostatic Test.—None or only small portions of measured quantities of sterile saline introduced into the bladder are returned by catheter. Cystoscopy may be of value.

B. EXTRAPERITONEAL RUPTURE OF THE BLADDER occurs through the base or lateral walls, and is followed by extravasation of urine and pelvic cellulitis.

1. The overdistended bladder may be ruptured by direct violence over the lower abdomen, the urine escaping into the prevesical space (of Retzius), infiltrating the cellular tissue toward the navel and laterally toward the anterior iliac spine, and behind the symphysis as far as the neck of the bladder.

2. With fracture of the pelvis, the anterior wall of the bladder close to the neck may be torn by the lateral fragment of the horizontal ramus or body of the pubis. The urine escaping into the cellular tissue, around the neck of the bladder, may ascend toward the abdominal wall or infiltrate the cellular tissue of the pelvis, and accumulate between the bladder and rectum. A dusky swelling often appears above the pubis and in the perineum, followed by rapidly fatal toxemia if the urine is septic. The patient may continue to void moderate quantities of urine, which may be blood-stained. The hydrostatic test is not dependable.

Prognosis.—From intraperitoneal rupture a diffuse peritonitis is well established by the third day, and death usually occurs on the fifth or sixth day from sepsis and urinary poisoning. With the extraperitoneal variety, the complications develop more slowly and are less dangerous, except for an occasional rapidly fatal cellulitis.

Treatment.—A. *Intraperitoneal Rupture:* Immediate abdominal section, evacuation of urine, closure of the opening in bladder, and placement of an indwelling catheter to prevent distention of the bladder until complete healing has occurred. The retrovesical pouch should be drained, if sepsis is evident.

B. *Extraperitoneal Rupture.*—Early drainage of perivesical extravasations by suprapubic and perineal incisions. To prevent further leakage an indwelling catheter should be introduced through the penile urethra, by a median urethrotomy, or a cystostomy performed.

Chronic perforation of the bladder not infrequently occurs from diverticulitis of the colon or other adjacent inflammatory or malignant disease. The treatment is that of the underlying disease.

Penetrating wounds of the bladder result from falls or stabs, gunshot injuries through the anterior abdominal wall, vagina, rectum, perineum, or buttocks, or through the sciatic foramen. The bladder may be accidentally opened in doing a celiotomy, herniorrhaphy, or appendectomy.

Treatment.—Closure by enfolding sutures, followed by the use of an indwelling catheter for one week.

Foreign bodies include: (1) Portions of catheters, lithotrites, and other instruments introduced by patient or surgeon; (2) pipe-stems, hairpins, pencils, and other objects introduced by the patient, usually for sexual excitation; (3) gauze sponges or pads, hemostatic forceps or other objects may ulcerate into the bladder from the peritoneal cavity, pessaries from the vagina, sequestra from disease of the pelvic bones, hair and teeth from ovarian dermoids, silk threads after pelvic operations.

Symptoms.—A foreign body may remain in the bladder for many years and cause a secondary stone, cystitis, and phosphaturia. A stony incrustation of phosphates upon the foreign body occurs.

Diagnosis is made by: (1) History, which may be misleading; (2) sounding; (3) cystoscopy, and (4) roentgenograms.

Treatment.—Removal of the foreign body through: (1) An open or operating cystoscope; (2) lithotrity and evacuation of fragments; (3) vaginal, perineal, or suprapubic cystotomy opening.

Vesical Calculus (Stone in the Bladder).—*Structure:* The stone consists of (1) a *nucleus* of a foreign body, mass of bacteria, renal calculus, or mucus; (2) a *body* of concentric layers of crystals, held together by mucus and colloid; (3) a *crust* of the most recent deposit, generally of triple phosphates if the urine has become alkaline.

Urinary calculi usually are single, but may be multiple.

Shape, round or oval; may show a cast of the adjacent bladder. *Encysted stone* is one lying in a diverticulum or the sac of a sacculated bladder. A very large stone may fill the bladder, which contracts about the stone. Multiple stones may show adjacent facets.

Varieties.—1. *Uric-acid stone* is most common, has a brownish or yellowish color, is oval or rounded, and laminated. It is associated with acid urine, occurring with an excess of nitrogenous foods, sedentary habits, febrile conditions, gouty diathesis, excessive sweating, and limited water-intake.

2. *Ammonium urate stone*—round or oval, lighter in color.

3. *Calcium oxalate stone*—dark brown or blackish, rough, nodular or mulberry-shape, very hard, deposited in acid urine, especially in nervous and dyspeptic patients.

4. *Phosphatic calculi* usually occur as a secondary deposit on a uric-acid or oxalate stone or foreign body, forming a white, soft, friable chalky mass deposited from alkaline urine as triple phosphates.

5. *Cystin stones* (yellow, waxy) are rare, as are the red *xanthin-cystin* stones.

Etiology.—Vesical calculus occurs chiefly in children under ten years, and in men after middle life, under poor hygienic surrounding conditions. Calculi are common in India and the tropics, where very hard water is drunk. Urethral and vesical obstruction, enlarged prostate, stricture, phimosis, vesical tumors predispose to the formation of stone.

The stone may originate from: (1) Small calculi from the kidney; (2) uratic sand of young boys; (3) foreign bodies, especially in young women and men; (4) retention and decomposition of urine.

Symptoms.—(1) Antecedent renal colic, the passage of sand and gravel, or an excess of uric acid or oxalates; (2) history of the retention of a foreign body; (3) pain increased by movement and at the end of urination, referred to the bladder or perineum, and radiating to the end of the penis; (4) pollakiuria; (5) hematuria at the end of micturition; (6) sudden arrest of the urinary stream, with resumption on change of position; or (7) urinary retention if the stone blocks the prostatic urethra. There is often incontinence of urine in children, and pulling at the prepuce, in boys. The secondary cystitis, vesical spasm, or tenesmus may cause sufficient straining to produce hemorrhoids or rectal prolapse.

Diagnosis.—1. *Roentgenogram:* In relation to their density, calculi have the following order—oxalate, phosphate, uric acid, and urates; the latter giving the faintest shadow. The shadow of a calculus should be differentiated from that of a calcified fibroid tumor, a tumor of the bony pelvis, phlebolith, calcified lymph-node, an enlarged prostate, or foreign substances in rectum or sigmoid.

2. *Sounding for Stones.*—The patient should be placed in a moderate Trendelenburg position, the bladder being distended by urine or boric acid solution. The beak of the sound is systematically rotated from side to side after introduction, and moved backward and forward. The prostate if enlarged is raised by a finger in the rectum. The metallic click heard and felt, indicating stone, is most marked with uric acid and oxalate calculi. Phosphate stones

Fig. 1000.—Vesical calculus. (Roentgenogram of Dr. G. C. Bird.)

give a softer grating. The sound may be masked by mucus or pus, or come from a prostatic calculus, prostatic débris on the vesical walls, or on a new-growth or ulcer.

3. *Cystoscopy* with an irrigating cystoscope reveals the position, size, number, and shape of the stones.

Treatment.—*Lithotrity* (crushing of the calculus) is always associated with *litholapaxy*, the evacuation of the fragments (Bigelow, 1878).

The patient is placed in the Trendelenburg position, the bladder irrigated by a catheter, and 200 to 300 c.c. of boric acid solution left in. The urethra is dilated by bougies to permit the easy passage of the lithotrite, which is introduced, directed toward the base and most dependent part of the bladder, widely opened, and gently closed until the stone is grasped. The blades are then ro-

tated to the center of the bladder to make sure that the walls of the bladder are not caught, locked, and the stone crushed by turning the screw of the instrument. The larger fragments are then picked up, and repeatedly crushed until small enough to pass through the evacuator. The largest size of evacuating catheter that can be used is introduced, attached to the evacuator and, by compression and expansion of the rubber bulb, the fragments removed from the bladder.

Indication for Litholapaxy.—Friable stones less than 4 cm. in diameter, in the absence of serious nephritis, or of stricture or enlarged prostate that would prevent the introduction of the necessary instrument.

After evacuation the bladder should be irrigated and examined through a cystoscope, to prove that no fragments remain.

Fig. 1001.—Bigelow lithotrite.

Perineal Litholapaxy (Keith's Operation).—The membranous urethra is opened in the midline of the perineum, and the lithotrite introduced through the wound into the bladder. This method is, rarely, employed when the necessary instruments cannot be introduced through the penis.

Lithotomy (cutting for stone) is preferred to litholapaxy: (1) When there is an associated condition, such as enlarged prostate requiring cystostomy; (2) when crushing is impossible on account of the size, density of the stone, or the presence of a foreign body that cannot be crushed; (3) when the lithotrite cannot be manipulated because the stone is encysted, the bladder contracted, or the stone impacted in the neck of the bladder. (4) When stricture, enlarged prostate, or other disease of the urethra prevents the introduction of the necessary instruments.

Fig. 1002.—Evacuator for removal of the crushed calculus.

Suprapubic Lithotomy.—A 6-cm. Pfannenstiel incision is made directly above the pubis, the peritoneum pushed upward, but not opened. The bladder is opened between guide-sutures or holding forceps, the stone removed by scoop or lithotomy forceps, the bladder closed or drained, dependent upon the presence of cystitis or other complication. Usually a small drain in the prevesical space is desirable.

Perineal lithotomy has a limited use, being especially indicated for smaller stones, impacted in the neck of the bladder or in the prostatic urethra. A grooved sound or staff is introduced into the bladder, and a knife carried by an oblique incision through the perineum into the groove, and thence into the bladder. A finger is introduced into the bladder as the knife is withdrawn, followed by stone forceps.

Vaginal lithotomy, the bladder being opened by a median incision through the vagina, is used in women.

Cystitis.—1. *Acute catarrhal cystitis* may follow exposure to cold, the use of irritants, as cantharides or turpentine, and is favored by the so-called "acid diathesis."

2. *Acute septic cystitis* may result from: (a) Traumatism either from accident, instrumentation or operation; (b) infection ascending from the urethra; as from a posterior urethritis in the male, or a colon bacillus infection from the external

genitals in the female; (c) foreign bodies; (d) extension of infection from contiguous organs, as the fallopian tubes, intestine, or appendix; (e) overdistension of the bladder followed by infection.

3. *Infection of the neck of the bladder* (*trigonitis*, *collitis* or *cystitis colli*) often complicates a posterior gonorrheal urethritis, is marked by frequency and urgency in urination, and pain in the perineum. With infection of the prostate there may be obstruction of the ejaculatory duct, pyoutricle, stricture of the ejaculatory duct or obliterative cysts of the prostate.

Chronic cystitis may be due to a foreign body or stone, tumor or parasitic invasion, an enlarged prostate, urethral stricture, tuberculous infection, or vesical paralysis from spinal disease. Acid urine in cystitis is associated with infection by the Bacillus coli, tubercle bacillus, gonococcus, streptococcus, and the B. proteus. Alkaline urine, with the Diplococcus (?) urea, B. proteus, staphylococcus, and B. coli in combination with alkali-forming organisms.

Pathology: The mucosa is red, swollen, ulcerated, or even gangrenous. The urine contains bacteria, leukocytes, pus, mucus, an excess of epithelial cells, and at times shreds, sloughs of mucous membrane, and blood. In chronic cases the urine becomes alkaline, ammoniacal, with phosphaturia and foul odor.

Complications: Toxemia, ascending pyelitis, pyelonephrosis, nephritis. The muscular wall may be thickened and hypertrophied, or thin and dilated with diverticuli.

Symptoms: (1) Dysuria, pain on urination with straining efforts (*urinary tenesmus*); (2) pollakiuria, frequent or constant desire to urinate; (3) pain in hypogastrium and perineum and, at times, associated rectal tenesmus.

Gonorrheal cystitis chiefly involves the neck and trigone, with great spasm and tenesmus.

Pneumococcal cystitis may be very acute, with great frequency and the passage of blood or clot at the end of micturition. Pneumococcus vaccine may be of value.

Typhoidal cystitis occurs in the later stages and during convalescence from the disease.

Cystitis from paraplegia, following injury or disease of spinal cord, develops rapidly without subjective symptoms, with purulent, alkaline, ammoniacal decomposition. Cystitis should be prevented by avoiding catheterization in paraplegia, the bladder being emptied reflexly by stroking the thighs or gently dilating the sphincter. If cystitis develops it should be treated by suprapubic cystostomy and irrigation.

Treatment of cystitis in acute cases includes: (1) Rest in bed, a milk and cereal diet, and removal of cause; (2) bland diuretics, 200 c.c. of water are given every hour, flaxseed lemonade and alkaline diuretics (as citrate or acetate of potash or soda) if there is excessive acidity; (3) anodynes to relieve spasm and pain, as belladonna, hyoscyamus, opium suppositories; (4) urinary antiseptics, methenamin, salol, benzoic acid; (5) oleoresins (as oil of sandalwood) are used in the acute stage, and cubeb and copaiba in the subacute and chronic stages; (6) irrigations and instillations. In subacute and chronic forms of cystitis, where there is much mucopus, the bladder may be irrigated by Janet's

method with a 1:5000 solution of permanganate of potash or nitrate of silver, a 3 or 4 per cent. solution of boric acid, or a 1/5 per cent. solution of acriflavin.

Janet's Method of Vesical Irrigation.—With the patient sitting or standing, the reservoir is placed 2 meters above the level of the bladder, connected by rubber tubing with an acorn-tipped urethral nozzle. With the nozzle firmly held against the meatus as the patient tries to urinate, the sphincter is forced by gravity and the bladder filled. The patient voluntarily empties the viscus.

Instillations of 10 to 50 c.c. of 20 per cent. argyrol are of value. In severe and intractable cases a suprapubic or vaginal cystostomy will place the bladder at rest.

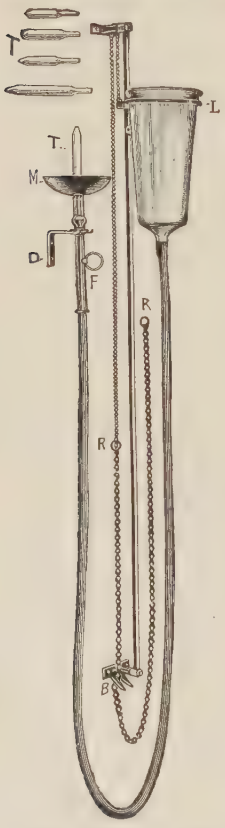


Fig. 1003.—Valentine's urethral irrigator with glass tips and sliding metal bracket used for irrigating the bladder and urethra.

Tuberculous cystitis follows tuberculosis of the kidneys, seminal vesicles, prostate, or epididymis; the bladder being relatively resistant. The bacilli entering the lymphatics invade the submucosa of the trigone and neck of bladder, and involve the orifice of the ureter forming a deep ulcerated pocket (*golf-hole ureteral orifice*). Miliary tubercles develop in the trigone, and coalesce, forming superficial ragged ulcers tending to spread over the bladder. With mixed infection an alkaline decomposition in urine occurs. The bladder walls finally become indurated and contracted, with a capacity of but 30 or 40 c.c.

Symptoms.—A young adult with a preceding tuberculosis of kidney, prostate, seminal vesicles, or epididymis develops vesical irritation with burning in the terminal urethra on micturition, and the expulsion of blood at the end of micturition. The symptoms may be aggravated at night. The urine may be pale and clear, or show shreds and pus.

Diagnosis is made: (1) By finding the tubercle bacillus in the urine, by staining, or the inoculation of guinea-pigs; (2) by a cystoscopic examination; or (3) by the discovery of an associated tuberculosis of the kidney, prostate, seminal vesicles, or epididymis.

Treatment.—(1) Removal of primary focus; (2) general treatment for tuberculosis. Irrigations are of limited value; boracic 4:100, or corrosive sublimate solution 1:10,000 may be used, nitrate of silver should be avoided. Full doses of sandalwood oil may be given by mouth. Methylene-blue, 0.01 to 0.02 gm. thrice daily, occasionally is of value, irrigation with a 1 to 5 per cent. solution of carbolic acid may be given once a week. In severe cases suprapubic cystostomy or ureterostomy relieves the tenesmus.

Animal Parasites.—*Filaria:* In filariasis the embryos may enter the urine, or interfere with the circulation of the urinary organs. Chyluria, often associated with hematuria and dysuria, is a characteristic symptom.

Bilharzia Hæmatobia.—The eggs are deposited in the submucosa of the

renal pelvis, ureter and bladder, penetrate the intercellular spaces between the glands, and enter the urine. The egg-shells become chitinous, causing the sandy patches seen on the bladder wall on cystoscopic examination.

Papules form which develop into sessile or pedunculated polyps, with associated catarrhal inflammation, discharge of mucus, thickening of the mucosa, calcareous deposits, and the formation of vesical calculi. Secondary malignant change is not uncommon.

In the ureter small submucous cysts develop and by obstruction cause secondary hydronephrosis, pyonephrosis, abscess of the kidney or septic nephritis. The kidney is rarely affected directly, although minute abscesses of the cortex occur. In the prostate, seminal vesicles and urethra, abscesses and fistulæ form, or a secondary hard infiltration occurs in the substance of the penis, with ulceration of the meatus and the formation of granulomatous and papillomatous growths.

Cysts connected with the bladder are found in the hypogastrium, originating from the urachus and, posterior to the bladder, arising from the prostate or seminal vesicles. Dermoid or hydatid cysts involve the bladder wall, and encroach upon the rectovesical pouch.

Tumors of the Bladder.—*Myoma*, *fibroma*, *myxoma*, and *angioma* are rare benign tumors of the bladder, and should, when they cause pressure-symptoms, be extirpated or destroyed.

Angioma should be treated by the application of radium, by fulguration, desiccation, or the injection of 30 per cent. solution of quinin and urea with a fine hypodermic needle.

Papilloma.—Villous and warty tumors, the common benign tumors of the bladder, occur chiefly in men between the ages of fourteen and forty. They consist of a branching core of fibroconnective tissue and blood-vessels, covered by transitional squamous epithelium. Papillomas may be single or multiple, usually are pedunculated, and grow chiefly from the trigone or about the ureteral orifices. They are especially common in workers in anilin dyes (Rehn). Malignant degeneration is not infrequent, especially of the sessile solitary warty growths.

Symptoms.—(1) Recurrent, apparently causeless hematuria, which may be uniform or more marked at the end of micturition; (2) interruption of urinary flow from pus or masses of tumor entering the urethra; (3) passage of particles of tumor; (4) secondary cystitis and calcareous incrustations.

Diagnosis.—Cystoscopic examination with an irrigating cystoscope, or the finding of bits of tumor in the urine.

Treatment.—Fulguration through a cystoscope. For large and multiple growths, suprapubic cystostomy with resection of the involved portion of the bladder wall, and suture; or the implantation of radium or radium emanation may be desirable.

Carcinoma of the bladder usually develops as a papillary squamous epithelioma, less frequently as a columnar-celled adenocarcinoma arising from the mucous glands.

Etiology.—Chiefly occurs in men over forty, often originating from a benign papilloma. The tumor forms a warty infiltrating mass, with a tendency to

necrosis, ulceration, and infiltration of the wall of the bladder. Phosphatic incrustation is common. Metastasis to adjacent lymph-glands or other organs is unusual.

Symptoms.—(1) Hematuria, less marked than with villous tumors, but more continuous; (2) obstruction of ureter or urethra; (3) infiltration of wall of bladder spreading to adjacent parts; (4) secondary cystitis, pyelonephritis, and uremia. Intense vesical tenesmus from cancerous infiltration, cystitis and the expulsion of blood-clots marks the later stages of the disease.

Diagnosis is made by cystoscopy and biopsy. An indurated mass may be felt through the rectum or vagina.

Treatment.—(1) Suprapubic cystotomy for exploration, local excision or destruction of the growth, or drainage; (2) resection of the bladder, especially in the early stage of cancer limited to the dome of the bladder; (3) total cystectomy for extensive growths around the ureters and trigone without invasion of adjacent organs, the ureters being implanted into the rectum or colon, or a bilateral lumbar nephrostomy or ureterostomy done; (4) cauterization, fulguration, or desiccation of the tumor; (5) implantation of radium or radium seeds through a cystoscope or a cystostomy opening for a growth that cannot be extirpated. Free use of opiates and a suprapubic cystostomy may be desirable in the later stages to relieve the vesical spasm.

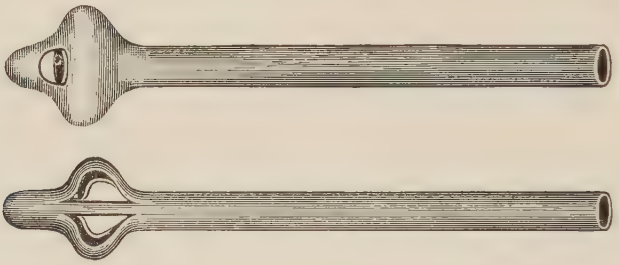


Fig. 1004.—Mushroom and Pezzer self-retaining catheters.

Secondary Carcinoma.—The bladder is subject to secondary invasion by carcinoma from the uterus, rectum, or prostate. Vesicovaginal or vesicorectal fistula often follows, especially after the destruction of the primary tumor by cautery or radiation. Extirpation or radiation is rarely of value for secondary growths. Fistula not complicated by malignancy may be closed by a plastic operation. A urinal may be worn, or in women an occluding pessary. Application of a 1 per cent. solution of acetate of lead and dusting the parts with zinc stearate are useful to reduce the local irritation.

Sarcoma of the bladder occurs in children and adults, and frequently springs from the dome of the bladder, forming a rapidly growing tumor felt in hypogastrium.

The growth may be treated by excision, radiation, or both. Recurrence is usual.

URETHRA

Congenital occlusion (*atresia* or *stricture*) should be treated by restoring the patency of the canal by incision or dilatation, secondary contraction being

prevented by the passage of sounds. Occlusion of the posterior urethra, and urethrorectal fistula, may necessitate a plastic operation through the perineum, often to be preceded by or associated with a perineal or suprapubic cystostomy.

Wounds.—The urethra may be injured in attempts at self-mutilation, and by accidental incised or gunshot injuries. The divided urethra should be accurately united by Lembert's sutures of 00 or 000 catgut over a catheter, the overlying tissues being closed in layers by fine catgut, silver wire, or horsehair. If the wound is extensive or urinary extravasation feared, the urine should be diverted by the insertion of a suprapubic or perineal indwelling catheter, until healing is complete. Secondary narrowing of the urethra should be prevented by the passage of sounds.

Contusion and rupture of the urethra usually follow falls astride a fence or other object, kicks or blows upon the perineum, or fracture of the pelvis. The urethra may be partially or completely divided with pain, retention or extravasation of urine, and secondary necrosis, abscess formation, or stricture. If the urethra has been ruptured, the urine should temporarily be diverted by an indwelling, suprapubic or perineal catheter, with a urethrorrhaphy or urethrostomy. Secondary extravasations or purulent or necrotic areas should promptly be drained by free incisions.

Extravasation of Urine.—1. With rupture of the urethra through or anterior to the anterior layer of the urogenital diaphragm (triangular ligament), the cellular tissue of the anterior part of the perineum, scrotum, penis, groin, and anterior abdominal wall are infiltrated. The attachment of the superficial perineal (Colles') fascia to the base of the urogenital diaphragm prevents the urine from passing backward, and that of the deep layer of the superficial fascia of the abdominal wall to the femoral fascia, prevents extravasation down the thigh.

2. With rupture through or posterior to the posterior layer of the urogenital diaphragm, the cellular tissue around the neck of the bladder, the prevesical space (of Retzius), the anterior abdominal wall, and the area between the peritoneum and transversalis fascia are infiltrated.

Treatment.—(1) Avoidance of attempts to urinate. (2) A soft-rubber catheter is gently introduced into the bladder, and tied in. (3) If the catheter cannot be introduced, an external urethrotomy is made over the area of rupture, the proximal end of the urethra found, the catheter introduced from the meatus to the bladder, and tied in. The urethra is sutured with provision for external drainage. If the proximal end of the urethra cannot be localized from below, it is demonstrated by a suprapubic cystotomy and retrograde catheterization. (4) For the urinary extravasation, which may be followed by a septic and necrotic cellulitis with suppuration and the formation of fistulæ, free incisions and ample drainage are desirable.

Foreign Bodies.—1. **Urethral calculi** are usually small and derived from the kidney, bladder or prostate, and may become impacted behind the urogenital diaphragm in the penile urethra, or in the fossa navicularis.

Symptoms.—Sharp cutting pains in the urethra on urination, with partial or complete arrest of the urinary flow, a bloody and later a purulent discharge from the urethra. A stone in the penile or anterior urethra may be palpated, or recognized from the grating on sounding, or shown by the roentgenogram or

urethroscope. Secondary enlargement, distention of the urethra, urethral ulcer, urethral abscess, or an obstructive ascending infection of the urinary tract may follow.

Treatment.—If the stone is small, it is usually expelled with forcible urination. To relieve pain, 1 per cent. of butyn or other local anesthetic should be injected, and expulsion by forcible urination tried. If not expelled spontaneously, the stone should be removed by forceps or scoop, with or without the aid of the urethroscope. If so impacted in the anterior urethra that the stone cannot be removed without serious damage to the mucous membrane, urethrotomy should be done. From the deep urethra the stone may be pushed back into the bladder by a large bougie, and then crushed and evacuated, or extracted by perineal urethrotomy.

2. **Foreign bodies from without**—including buttons, pencils, hatpins, pebbles, pipe-stems—may be introduced by children or the insane, as a playful prank or an attempt at sexual gratification. Urethritis, ulceration, abscess formation, extravasation of urine, or ascending infection through urinary obstruction may follow. Methods of removal are similar to those described for urethral calculus.

With a hatpin, where the head cannot be located, the point may be forced through the floor of the urethra and overlying skin, the direction of the pin reversed, and the head pushed out of the meatus. Death has followed neglected obstruction of the urethra by such a small foreign body as a dried pea.

Urethritis.—A. **Simple Urethritis (Non-gonorrheal Urethritis)**: The urethra is resistant to pyogenic micro-organisms except the gonococcus. Acute urethritis, however, may follow: (1) *Infection* by the colon bacillus, the staphylococcus, the Micrococcus catarrhalis, and other micro-organisms, which may enter the urethra with a leukorrheal discharge or from an infection of the upper urinary tract; (2) *traumatic injury*, especially the passage of catheters or other instruments, the use of an indwelling catheter, or the presence of foreign bodies within the urethra; (3) the *injection of chemicals*. Chemical urethritis usually follows injections of strong solutions for the eradication of venereal disease; (4) in *arthritis* and certain general infections.

Symptoms are thin mucopurulent discharge from the urethra, moderate dysuria and pain, usually disappearing spontaneously within a few days.

Treatment includes the removal of the cause, the free use of water, and at times gentle irrigation or injection of the urethra with such non-irritating solutions as 4 per cent. boric acid solution, 2 per cent. argyrol, or 1 per cent. acetate of lead.

B. **Gonorrheal urethritis** (*gonorrhea, neisserian urethritis, specific urethritis, clap*) is a contagious infection of the urethra, due to the gonococcus of Neisser (*Neisseria gonorrhœæ*, 1879). Infection in men occurs almost invariably from sexual contact, in women and children infection may be caused by pus carried on the hands, towels, clothing, toilet seat, or other articles. A residual chronic infection, very common and persistent, may be relighted into activity by the use of alcoholics ("*beer-test*"), sexual excess, the passage of instruments, the use of vaccines, irrigations, or injections. Outside the body the gonococcus is easily destroyed by drying, heat, cold, or sunlight. In the body it attacks

mucous and serous surfaces, but does not produce reaction or suppuration in muscle, fat, or skin. On mucous surfaces the gonococcus penetrates between the columnar epithelial cells, invades the mucous glands, enters the epithelial cells, and produces infiltration and fibrosis in the submucous connective tissue. It does not cause suppurative lymphadenitis, *gonorrheal bubo* being due to a mixed infection.

Symptoms.—1. *Incubation period* varies from two to five days.

2. *Onset.*—Usually two to four days after exposure, the patient notices itching at the meatus followed by heat, smarting, and scalding on urination. The meatus is reddened, slightly swollen, and a drop of mucopurulent secretion may be expressed which, drying, glues the lips together.

3. *Second Stage (Stage of Purulent Catarrh).*—By the end of the first week the discharge has become more profuse and purulent, and finally there is a free discharge of thick greenish pus, which usually continues for from two to six weeks or longer. There is urinary frequency, severe burning, stinging pain on urination, and local tenderness. The infiltrated, inelastic corpus spongiosum produces a painful curvature of the penis on erection (*chordee*), which may greatly disturb the patient at night. There is pain and tenderness.

4. *Third Stage (Subsiding Stage).*—After about six weeks the discharge decreases and becomes thinner, mucoid, milky or watery (*gleet*). The acute inflammatory symptoms disappear, the discharge may only be noticed in the morning (*morning-drop*). This stage may continue for many months.

5. *Chronic urethral infection* is common and often persists for many years, infection being shown by purulent shreds in the urine (first glass), and erosion, ulcers, strictures, granular patches, polypoid masses, or cystic obstruction to glands found on examination of the urethra. In the subsiding or chronic stage, the inflammation may be relighted into activity by the use of alcoholics or local irritation.

Complications.—A. *Anterior Urethritis:* (1) Infection of the urethral (Morgagni's) lacunæ and the small urethral glands; (2) chordee; (3) bubo, enlargement and suppuration of the inguinal lymphatics, is much less common than in chancroid; (4) periurethral abscess follows suppurative infection with obstruction of the urethral glands; (5) stricture may result from periurethral fibrous induration, or infiltration and ulceration of the mucosa; (6) balanitis (balanoposthitis) usually is associated with phimosis, and often requires a dorsal slit of the foreskin for exposure and proper treatment; (7) lacunar abscess may rupture, forming penile fistula; should be treated by early incision, if possible, through the urethra; (8) acute retention of urine may be due to swelling or spasm, and should be treated by hot sitz-baths, hot compresses, hot irrigation of the rectum, and the use of atropin and morphin; catheterization should be avoided if possible; suprapubic aspiration of the bladder may be necessary; (9) cowperitis, purulent inflammation of bulbo-urethral (Cowper's) glands, is at times followed by an abscess which may rupture through the anterior layer of the urogenital diaphragm (triangular ligament) to the skin, through the deep layer into the ischiorectal fossa, or rarely into the rectum; (10) venereal warts.

B. *Posterior Urethritis.*—Infection extends from the anterior to the posterior urethra in over 50 per cent. of the cases, usually between the first and

third weeks. There is increased urgency and frequency in urination, pain referred to the perineum, bladder or rectum, and at times acute retention.

Complications of posterior urethritis include: (1) *Vasitis* and *epididymitis;* (2) *vesiculitis;* (3) *prostatitis;* (4) *trigonitis* and *cystitis.*

Treatment of Acute Gonorrhea.[1]—1. *Prophylactic treatment* is valuable up to twelve hours after exposure. The patient should urinate, thoroughly wash the genitals and adjacent parts with soap and water, followed by a 1 : 2000 sublimate solution. The urethra is then distended for five minutes by injecting a 2 per cent. protargol or a 10 per cent. argyrol solution. As an additional prophylactic against syphilis, 33 per cent. calomel ointment is thoroughly rubbed into the penis and scrotum, the U. S. formula being: Hydrargyri chloridum mite, 30 parts; adeps benzoinatus, 65 parts; cera alba (U. S. P.), 5 parts.

For the female patient the genitals are washed with soap and water, and a douche of 2 quarts of sterile water at a temperature of 100° F. is followed by 2 quarts of a 1 : 2000 mercuric chlorid solution, which is also used to wash the external parts. The vagina is then thoroughly swabbed with freshly made 2 per cent. protargol, or a 10 per cent. argyrol solution, paying especial attention to the orifices of Skene's and Bartholin's glands. This solution is also injected into the urethra, in which it is retained by pressure of the gloved finger for three to five minutes. A douche of sterile water is then used, the parts dried, and a calomel ointment applied to the cervix, vagina, vulva, and adjacent regions, not using more than 4 gm. in the vagina, ten minutes, time being consumed in the process. The vulva is then covered with waxed paper, and the ointment should not be removed for several hours.

2. *Abortive treatment* is occasionally successful during the first twenty-four or forty-eight hours of discharge, and before the secretion has become profuse or purulent.

(a) Immediately after urinating, the mucosa is anesthetized by injecting 4 c.c. of a 1 per cent. solution of butyn, which is retained for four minutes; 4 c.c. of a 2 per cent. solution nitrate of silver are then injected into the anterior urethra only, and retained for five minutes.

(b) Every four hours, over a period of twenty-four hours, the anterior urethra is distended for five minutes by one of the following solutions: Argyrol 5 per cent., protargol 2 per cent., acriflavin 1 : 4000, mercurophen 1 per cent. The patient sits upon a folded towel to cut off the posterior urethra.

Acute Stage.—The patient should preferably remain in bed for one week, and should avoid alcoholics, coffee, tea, meat and meat extracts, stimulating and spicy foods, and condiments. Two hundred cubic centimeters of water should be taken every hour while awake. Only mild non-irritating injections should be used and, if the condition is hyperacute, all local treatment should be omitted. Alkalies should be avoided, as an acid urine reduces the tendency to an ascending cystitis. A bag or gonorrheal apron should be worn to catch the discharge, no constricting or occlusive dressing being employed. The penis should be held in water as hot as can be borne for fifteen minutes every four hours or hot sitz-baths or hot fomentations used. From 8 to 15 minims of santal oil may

[1] The manual of the Surgeon-General's office has largely been followed.

be given three times daily after food to reduce the *ardor urinæ*. If the local reaction is not intense, local treatment with injections of mild non-irritating antiseptics may be given with an acorn-tipped syringe of a capacity of 5 c.c., using 5 per cent. argyrol or 1 per cent. protargol. The solution should be freshly made, the injection gently given immediately after urinating every two hours, and held in the urethra for five minutes.

Subacute Anterior Urethritis.—Patients running a favorable course reach this stage in from ten to twenty-one days. The acute symptoms subside, the discharge becomes scant and watery, but few gonococci are found in the discharge, and the first test glass is only slightly turbid. A relapse will occur in from two to three weeks if treatment is now discontinued. Irrigation treatment with mild astringents is especially valuable.

Technic.—The patient sits upon the edge of a chair or stands, holding a basin to catch the overflow. The irrigator tip is pressed against the meatus and the anterior urethra distended by fluid, the pressure of the tip of the irrigator against the meatus being intermittently released to cause thorough irrigation of the anterior urethra. To reach the posterior urethra, the reservoir is raised to the height of 2 or 3 meters above the level of the genitals, after the anterior urethra is first thoroughly washed out, the tip firmly pressed against the meatus, and the urethra dilated as the patient takes a deep breath and attempts to urinate, thus releasing the cut-off muscle so that the irrigating fluid flows back into the bladder (Janet's method). When the bladder is filled the patient empties it by urinating. The irrigating fluid should be at a temperature of 110° to 115° F., or as hot as can be comfortably borne. *Potassium permanganate* (1 : 5000 to 1 : 3000) is useful where there is free purulent discharge and few micro-organisms; this may be given three or four times daily if it does not cause reaction. *Nitrate of silver* in strengths of 1 : 5000 to 1 : 3000 in distilled water is especially valuable, acting as an astringent and destroying residual infection, especially where the urine is clear and only contains shreds of pus and mucus. It should be given daily or on alternate days. *Mercuric oxycyanid* in strengths of 1 : 5000 to 1 : 3000 is beneficial where there is a purulent, non-gonococcic, bacterial urethritis. It should be avoided if the patient is taking iodin or iodids.

Cure is indicated by disappearance of (1) urethral discharge and (2) shreds from the urine, even after massage of the prostate and vesicles, and the (3) absence of constriction or stricture of the urethra. A mucous discharge may persist from the irritation of the injections or irrigations, and may only disappear after these are discontinued.

Acute posterior urethritis develops after the second week of an acute anterior urethritis in about one-half of the cases of gonorrhea. Turbidity from pus is found in the second glass with the two-glass test. Severe pain and vesical tenesmus may be present. In the acute stage the patient should be placed in bed, given a cereal and milk diet, vesical spasm relieved by free use of water, oil of sandalwood, and opium and belladonna suppositories. Hot sitz-baths, several times daily, are useful. Alkalies should be avoided. The condition usually promptly subsides into a subacute posterior urethritis, which may then be treated by urethrovesical irrigations by the gravity method; silver nitrate 1 : 10,000 to 1 : 4000, or potassium permanganate 1 : 5000 to 1 : 3000, being used. Injections through a soft-rubber catheter, introduced just beyond the cut-off muscle, of about 1 c.c. of a 1 : 500 or 1 : 100 solution of silver nitrate, of 20 per cent. argyrol, Dakin's solution, or 1 per cent. mercurochrome are also of value.

Treatment of Complications.—*Folliculitis:* Pus collects in one of the

urethral follicles, forming a small abscess which may rupture into the urethra or, if upon the skin, leave a troublesome persistent fistula. The tender mass is detected by palpation, and the abscess should be opened through a urethroscope from within the urethra.

Chordee.—The patient should urinate immediately before retiring, using a hot sitz-bath or a prolonged immersion of the penis in very hot water. He should sleep in a cool room, lightly covered, and avoid lying upon the back. On waking with chordee, the penis and testicles should be immersed in cold or hot water, and the bladder emptied. The patient should be warned not to break a chordee. Sodium or potassium bromid, 0.3 to 1.0 gm., given in the afternoon and on retiring, is useful, and a morphin rectal suppository may be necessary.

Epididymitis.—The patient should immediately be placed in bed, all injections and instrumentation stopped, the testicles elevated by sling or bandage and hot applications (sitz-baths or hot fomentations) used. If the symptoms are severe, an epididymotomy, or puncture by a von Graefe cataract knife, promptly relieves the pain and hastens recovery. After the acute symptoms have passed the patient should continue with a suspensory bandage, apply yellow oxid-of-mercury ointment daily, and local treatment should be resumed only after all symptoms have disappeared, and then with great care.

Acute prostatitis should be treated by rest in bed, sandalwood oil, sitz-baths, hot fomentations or poultices to the perineum, hot rectal irrigations, opium and belladonna suppositories. Catheterization should be avoided if possible.

Prostatic Abscess.—Small multiple abscesses usually empty into the urethra, and there is but slight reaction. If the temperature rises, if chills occur, if there is no improvement within a week, and if a large tender prostate is found on rectal examination, the abscess should be opened by a transverse incision through the perineum and prostate, or by a perineal urethrotomy; the mucous membrane of the prostatic urethra being penetrated by the finger, and the pus evacuated.

Acute Seminal Vesiculitis.—The treatment is similar to that for acute prostatitis, avoiding all injections into the urethra or massage of the vesicles.

Chronic Gonorrhea.—Examination of the patient should include: (1) Study of urethral smears; (2) a two- or three-glass test of the urine; (3) palpation and expression of prostate and vesicles, and gross and microscopic examination of the fluid expressed; (4) a *bougie à boule* examination (size No. 26 or 28 French) of the urethra for stricture with a meatotomy if necessary; (5) endoscopic examination of the anterior and, at times, the posterior urethra.

Granular patches are found on the urethra from an infiltration of small, round cells underneath the mucous membrane, surrounding the urethral (Morgagni's) lacunæ and urethral (Littré's) glands. The infiltration, if superficial, is absorbed; if deep, converted into fibroconnective tissue, forming a stricture. When there is a general catarrh indicated by the turbidity in the first glass, irrigations of nitrate of silver or permanganate of potash solution every day or every alternate day are continued, until the first urine passed is no longer turbid but contains only shreds from local erosion, or comma-shaped particles, formed in the open mouths of the prostatic ducts and Morgagni's crypts. This usually continues

until the submucous infiltration is absorbed. Steel sounds (28 to 36 French) are now used to fully dilate and stretch the urethra. Sounding should not be done during acute inflammation, or before the urine is clear and contains only shreds. A meatotomy is often necessary. With soft recent infiltrations, the sounds are introduced every four to seven days; with hard organized infiltrations, every week; always waiting for the reaction from the previous insertion to completely subside.

Glandular Urethritis.—Chronic inflammation of the urethral lacunæ (Morgagni's crypts) may cause a morning-drop, with exacerbations of discharge on slight provocation for years. The urethroscope shows the mouths of the crypts red, open, pouting, with elevated edges or occluded by a growth of epithelium.

Treatment.—Full dilatation by sounds, followed by irrigations and local destruction of residual glands by a galvanocaustic needle, or by 10 per cent. solution of nitrate of silver.

Chronic posterior urethritis is usually due to the gonococcus, but may also follow excessive sexual excitement, or perineal traumatism as from horse-back riding. The two-glass test may show turbidity in both "1" and "2," with comma-like threads from the mouths of the prostatic ducts (Furbinger's hooks). The urethroscope shows the posterior urethra purple, hemorrhagic, granular, swollen; with an edematous colliculus, and often small polyps on its surface. In the later stages the colliculus is finely irregular and grayish white.

Treatment.—Urethrovesical irrigations by gravity of silver nitrate (1 : 10,000 to 1 : 4000 solution) or potassium permanganate solution (1 : 3000). After the urine has become clear, prostatic massage is used for the infiltration of the colliculus, and a 10 to 20 per cent. silver nitrate solution directly applied, once a week through the endoscope. The cauterization of granulations with strong nitrate of silver solution, and the removal of polyps or granulations by forceps or cautery are valuable. The infected utricle should be injected with a 4 per cent. silver nitrate solution with a small syringe.

Prostatitis.—The prostate is usually involved in chronic posterior urethritis, and prostatitis is one of the most frequent and important complications of gonorrhea. It may continue for years, is a source of infection, causes profound disturbance of the nervous system, and in time, of the sexual function.

Treatment includes relief from constipation by saline cathartics, and the removal of sources of erotic excitement. Prostatic massage two or three times weekly (both lobes being massaged from above downward with moderate pressure) is to be tried, but not to be continued if it causes irritation. To prevent epididymitis the urethra may be irrigated, and the bladder filled before massage with a solution of nitrate of silver of 1 : 10,000 to 1 : 4000. Massage and irrigation should be continued for six to eight weeks, until the microscopic examination of expressed prostatic secretion shows only a small number of pus-cells. When improvement no longer continues the treatment is intermitted for one month, and then resumed if the prostatitis has not disappeared. When the expressed prostatic secretion shows only 4 to 6 pus-cells to a field, with abundant lecithin bodies, the patient may be considered as cured. An associated posterior urethritis should carefully be treated.

Chronic seminal vesiculitis arises from extension of a posterior urethritis

through the ejaculatory ducts. It may be atonic or inflammatory or often is a combined form.

Treatment.—(1) Massage of the vesicles is used twice weekly, but is to be avoided in acute vesiculitis, where there is blood in the expressed material, or excessive tenderness. (2) Treatment of the posterior urethra as previously described. The treatment often requires six to twelve months. There may be associated sexual neurasthenia, gonorrheal rheumatism, and injection or incision with drainage of the seminal vesicles may be required.

Cure of gonorrhea is indicated by: (1) Absence of urethral discharge; (2) absence of gonococci from the secretions; (3) absence of pus-shreds from glass "1" and glass "2" (epithelial shreds free from gonococci may be disregarded); (4) absence of gonococci, and but few leukocytes in the secretions obtained by massage of the prostate and seminal vesicles; (5) absence of stricture as shown by a *bougie à boule*. The urethra should not be dilated on the same day that massage is performed. Vigorous exercise should be taken the day before examination, to determine the cure of gonorrhea. In case of doubt, without urethral discharge, a provocative irrigation of the urethra with nitrate of silver 1 : 1000 may be made. If infection is present, the gonococci will be found in the discharge which follows a few hours later.

Gonorrhea in Women.—(1) *Before puberty*, the vaginal mucosa is less resistant, and vaginitis and vulvitis are the common lesions. (2) *During menstrual life* there is endocervicitis, less commonly urethritis; infection of the glands of the introitus is secondary; vaginitis is exceptional, and infection of the uterus and tubes not infrequent, especially during menstruation. (3) *After the menopause* the cervix and urethra usually are chiefly infected. During pregnancy there often is vaginitis and condyloma formation.

Treatment.—Douches of 6 to 8 quarts of water under low pressure, while lying down. These should be omitted during menstruation. With acute cervicitis and endocervicitis a large douche of plain water, followed by 2 quarts of 1 : 2000 silver nitrate solution or potassium permanganate solution at a temperature of 110° F., three to four times a day during the period of profuse discharge. After the acute reaction has subsided, the cervical canal is dried and swabbed with 10 per cent. nitrate of silver or pure tincture of iodin twice a week. Bleeding indicates overactive treatment, and should not be produced. Later the topical application of nitrate of silver 20 per cent. to erosions and infected patches, and destruction of infected nabothian follicles by the cautery are used, as indicated.

Acute Vaginitis: Douches, soft tampons of 1 : 2000 silver nitrate, 5 per cent. protargol, or 10 per cent. argyrol may be used. Condyloma may be dusted with A. B. C. powder or destroyed by the galvanocautery. For vulvitis with local irritation, applications and compresses of 2 per cent. lead acetate solution are astringent and soothing.

Bartholinitis.—Inflammation of the greater vestibular glands. In the acute stage, rest in bed, hot applications, and incision and drainage as soon as abscess has formed. Chronic infected glands should be excised.

Urethritis.—Prolonged hot antiseptic douches are first used; as the condition becomes subacute, bougies of 10 per cent. argyrol, 10 per cent. bismuth subiodid,

5 per cent. protargol in cacao butter are inserted after urination. The application of a 10 per cent. nitrate of silver solution through an endoscope to erosions is useful in resistant cases, or the introduction of sounds coated with 10 per cent. protargol ointment twice a week, preceded by the emptying of the bladder. Stricture is very rare. Skene's or periurethral ducts, when infected, should be treated by injecting a 10 per cent. solution of nitrate of silver through a fine needle, or destroyed by a fine galvanocautery needle.

Cystitis is to be treated as in the male.

Metritis and Endometritis.—Rest in bed; at first cold, later hot applications over the lower abdomen to relieve pain; hot douches. Menorrhagia is to be treated by hot douches, and tampons. Curettage, or intra-uterine applications during an acute endometritis may be followed by purulent salpingitis and should be avoided.

Acute Salpingitis.—Rest in bed, opium suppositories, and hot douches and sitz-baths if these do not increase the symptoms. Later daily 5 per cent. ichthyol and glycerin tampons, with the local application of heat. *Tubal abscesses* in the acute stage are best drained through a posterior vaginal section.

Chronic gonorrheal salpingitis should be treated by salpingectomy; if there is chronic involvement of the uterine endometrium, an associated hysterectomy may be desirable.

Gonorrheal vulvovaginitis is common in little girls, highly infectious, and may spread among the children of a family or institution. The external genitals become red, edematous and swollen, and there is usually a free purulent discharge containing gonococci.

Treatment.—Prophylaxis: Great care should be taken to prevent the spread of the infection by contact with contaminated towels, wash-rags, clothing, toilet seat, bath tub, hands, and the like, by methods of segregation, sterilization, and disinfection.

Vaginal and vulvar irrigations four to five times daily with a 1 : 10,000 to 1 : 5000 solution of oxycyanid of mercury, followed by the instillation by a pipet or small soft-rubber catheter of a 5 per cent. solution of argyrol. For the external irritation, compresses of a 2 per cent. solution of acetate of lead containing $\frac{1}{2}$ per cent. of phenol are useful.

Stricture of the Urethra.—*Varieties:* (1) Spasmodic stricture due to muscular spasm; (2) congestive stricture due to congestion or inflammation of the mucous membrane; (3) organic stricture due to the contraction of cicatricial tissue in the urethral wall.

1. **Spasmodic stricture** involves the membranous urethra from spasm of the transversus perinæi profundus and sphincter urethræ membranaceæ (compressor urethræ muscle), the spasm being due to: (1) Gonorrhea or other form of urethritis; (2) reflex irritation from the anus, rectum, or other adjacent organs; or to (3) neurosis or hysteria.

Treatment.—Hot fomentations, hot sitz-baths, hot rectal irrigations, morphin and belladonna suppositories. If these measures fail, catheterization by a small soft catheter may be necessary. The introduction of an instrument is resisted through the muscular spasm, but is overcome by continued gentle

pressure. In acute gonorrhea, suprapubic aspiration of the bladder may be preferable to the introduction of a catheter.

Organic or Cicatricial Stricture.—(1) The *prostatic* urethra is rarely involved by stricture; (2) the *membranous* urethra may be strictured following traumatism; (3) the *spongy* urethra is chiefly affected by spasmodic, congestive, inflammatory and traumatic strictures. The stricture is: (a) *Annular;* (b) *ribbon;* (c) *bridled*, with a band across the lumen; (d) *resilient* (tending to recur after dilatation); (e) *callous*—dense and unyielding; (f) *permeable;* (g) *impermeable*, or *impassable*. *Urethral stricture* is usually due to traumatism or gonorrhea,

Fig. 1005.—Van Buren's sound. The sizes range from 8 to 40 French.

Fig. 1006.—Urethral sound. Benique curve.

Fig. 1007.—Gouley tunnelled sound introduced over a filiform bougie.

more rarely a urethral chancre or non-specific urethritis. Stricture may follow impaction of stone or foreign body, instrumentation, cauterization, or abscess.

Secondary Changes.—Behind the stricture the urethra may dilate, pockets with stagnant secretions collect, and infection progress. The bladder shows secondary hypertrophy, trabeculation, pouching, or distention and thinning. Secondary interstitial nephritis, pyelonephritis, or pyonephrosis may follow.

Symptoms.—Reduction in size and force of the urinary stream, straining and secondary dribbling, mucopurulent discharge. The symptoms may be increased by exposure to cold or after indulgence in alcohol. Retention with dribbling and overflow may follow, or associated infection, rupture of the urethra, and extravasation of urine occur. A fibrous mass may be palpated. The caliber,

length, and situation of the stricture is determined by passing *bougies à boule* of various sizes.

TREATMENT.—*Dilatation* of the stricture may be *abrupt* or *gradual*, *intermittent* or *continuous*.

Abrupt Dilatation: Under local or general anesthesia a meatotomy is done, if necessary, and the largest size steel sound that the urethra will admit introduced to the stricture. With the point of the sound in the exact line of the urethra, the sound is pushed through, divulsing the strictured area. A large sound produces a false passage less often than a small one. The urethra is distended with sterile olive oil before the introduction of the sound. This method is often successful, dilating strictures through which it is difficult to pass sounds and bougies of small size.

Gradual Dilatation: The urethra is gradually dilated at intervals of three to ten days by sounds of progressively increasing size. The method is useful for soft and non-resilient strictures of moderate size. After full dilatation a full-sized sound should be passed at first weekly, later monthly, and then once or twice a year, until all tendency to contraction has been overcome.

Continuous Dilatation: Used for very small and almost impassable strictures. Many filiform bougies are introduced through an endoscope to the stricture and if one or more can be passed to the bladder these are left in place for twenty-four hours, when additional bougies or bougies of larger size are introduced; or a catheter of the largest size that can be passed through the stricture may be tied in and left, to soften and dilate the stricture. *Urethritis*, *periurethral abscess*, or *epididymitis* may follow continuous dilatation, which is more dangerous than intermittent dilatation.

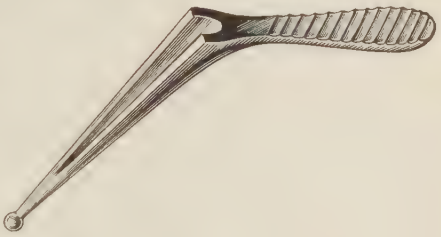


Fig. 1008.—Teale's blunt gorget.

Internal urethrotomy by *Civiale's* or *Maisonneuve's* urethrotome (the former cutting from behind forward, the latter from before backward) is used for resilient, valvular, and bridle strictures, and when dilatation fails. The incision is made on the roof of the bulb, or on the floor of the penile urethra. The operation is done under local or general anesthesia, and should be followed by intermittent dilatation by steel sounds until there is no further tendency to contraction.

External urethrotomy is used for impermeable strictures, and those complicated by periurethral infections, false passage or urinary extravasation, and in acute traumatic stricture.

Syme's method consists in introducing a shouldered grooved staff, the end of which passed through the stricture is used as a guide.

Wheelhouse's operation is used for impassable or impermeable strictures. The Wheelhouse staff being introduced to the stricture, an incision is made in the middle line upon the staff. The stricture is then divided, and a free passage through to the bladder established.

Cock's Operation (*External Urethrotomy Without a Guide*).—A finger is introduced into the rectum to the prostate, an incision is made in the midline of the perineum (about 3 cm. in front of the

anus) into the membranous urethra, and the stricture located and divided. Where the stricture cannot be located, retrograde catheterization after a suprapubic cystostomy or after opening the deep urethra may be necessary. An indwelling catheter is left in place for ten to twelve days. The overlying skin is not completely closed.

Resection of the urethra (*plastic urethrotomy, urethroplasty*) is used where there has been extensive destruction of the urethra from traumatism or infection. The urethra is exposed, the fibrous area resected, the urethral ends liberated, and united over a soft-rubber catheter. Where a large gap remains, a section of a recently removed vermiform appendix, or an Esser inlay skin-graft upon a catheter may be implanted; the urine being diverted from the operative field during the period of healing, by a perineal urethrotomy or a suprapubic cystostomy.

Complications of Stricture.—1. *Acute retention* of urine may follow cold, exposure, or dissipation, and be aggravated by local spasm and congestion of the urethra. Hot baths, opium and belladonna suppositories are tried; if

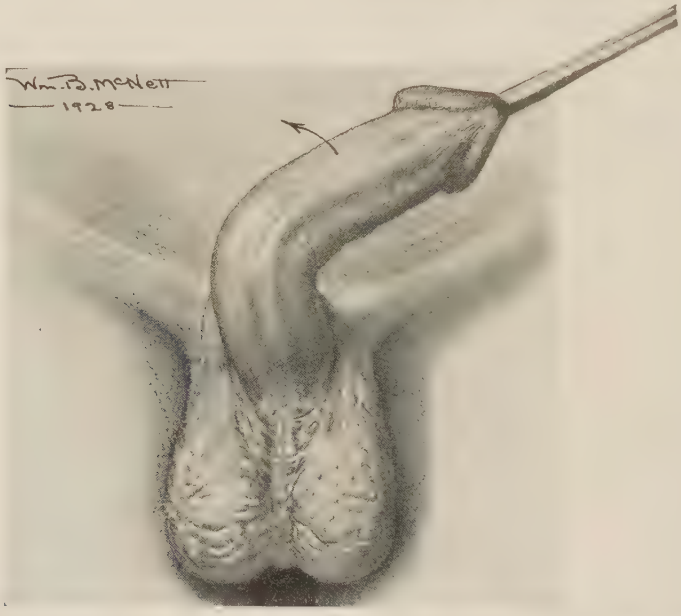


Fig. 1009.—Introduction of urethral sound (first stage). Introduction is started with the sound parallel with the ligament inguinali until the tip of the instrument has passed the penile urethra, when the shaft is swung to the midline of the body.

these fail, a catheter is passed or one or more filiforms introduced and left in to gradually dilate the channel and permit the escape of urine. If, however, there is acute infection of the urethra, suprapubic aspiration of the bladder may be preferable. For an impermeable stricture or false passage, external urethrotomy is indicated with the use of an indwelling catheter.

2. *Periurethral cellulitis* and urinary extravasation. The urine usually escapes into the tissues of the perineum, scrotum, and penis, with marked redness, swelling, and brawny induration, followed by the formation of sinuses and fistulæ or by rapid necrosis and moist gangrene. The patient is often middle aged or elderly. The process may extend to the anterior abdominal wall with grave systemic symptoms, including high temperature, chills, and fever.

The treatment is immediate perineal urethrotomy, free incisions into the infiltrated tissue being made to permit the escape of the foul pus, urine, and sloughs. A catheter may be fastened in the bladder, and the wounds left open to granulate. Hot wet boric-acid compresses, or compresses of aluminum acetate are of value.

3. *Periurethral abscess* may result from suppuration of the bulbourethral or Cowper's glands, and may rupture externally with the formation of a urinary fistula. The abscess, if possible, should be drained through the urethra; if this is not feasible, external urethrotomy is used.

4. *Urinary fistula* from extravasation of urine or periurethral abscess usually open on the perineum or scrotum. A perineal fistula tends to close spontaneously when the urethra is without obstruction. If the fistula has acquired an epithelial lining, this should be destroyed by caustic or excised.

Fig. 1010.—Introduction of sound (second stage). The sound is swung to midline of body.

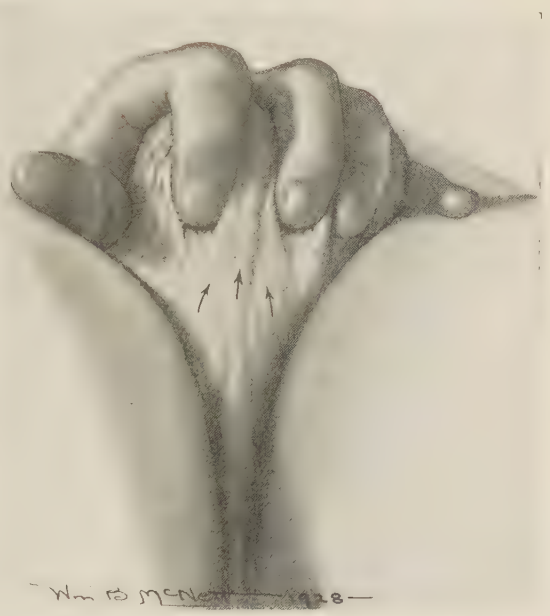


Fig. 1011.—Elevation of scrotum to put urethra on the stretch to facilitate the passage of the sound through the urogenital diaphragm.

Penile and *rectal fistulæ* are persistent, and often require operative excision and plastic closure. For success, especially with penile fistulæ, the urine should be diverted by perineal or suprapubic cystostomy.

Catheter or Urinary Fever.—A violent chill, fever, and sweat may follow the passage of a catheter or other instrument, particularly in forms of subacute deep urethral infection. The condition is usually transient, but may be followed by other evidences of infection, as a prostatic abscess, epididymitis, or periurethral phlegmon. It should be treated by the avoidance of instrumentation, and the free use of water and quinin, in association with coal-tar antipyretics.

PROSTATE GLAND

Injuries of the prostate usually result from unskilful instrumentation; rarely, from stab or gunshot wounds.

Acute Prostatitis.—Etiology: (1) Posterior urethritis, especially gonorrheal; (2) infection or injury from instrumentation; (3) urethral or prostatic calculus.

Symptoms.—Rectal and vesical tenesmus, burning pain in the perineum, prostatic shreds and pus in the urine, enlarged tender prostate felt by rectum, with at times a brawny swelling in the perineum. A prostatic abscess is associated with chills, fever, priapism, hematuria, retention of urine. The prostate

Fig. 1012.—Passage of sound through the deep urethra. Scrotum is elevated as the handle of the sound is depressed.

feels hot, swollen, tender, and may fluctuate. The abscess ruptures into urethra or, less frequently, into the rectum, bladder, or perineum, with occasionally a residual fistula. Secondary cystitis and renal sepsis may follow.

Treatment.—Rest in bed, a bland milk and cereal diet, an excess of liquids, the use of laxatives, hot rectal douches and irrigations, suppositories of belladonna and opium, fomentations to the perineum, hot sitz-baths, and gentle catheterization by small soft catheter only if persistent retention of urine occurs. Large abscesses may require evacuation by a median or lateral perineal incision, or through the urethra.

Chronic prostatitis may follow an acute prostatitis, posterior urethritis, gonorrhea, cystitis, impacted prostatic or deep urethral calculus, or a stricture.

Symptoms.—Pollakiuria, slight terminal dysuria, pressure and distress referred to perineum; prostatorrhea, discharge of milky tenacious fluid after urination, defecation or prostatic massage, with mucous casts of the prostatic glands. Priapism or impotence and nocturnal emissions may be associated.

Treatment.—The passage of large sounds, followed by prostatic massage and the instillation of 20 per cent. mild silver proteid in the deep urethra every three to six days. Suppositories of belladonna, ichthyol, and calomel. Abscesses should be evacuated and calculi removed.

Cysts of the prostate occur in chronic prostatitis, may obstruct the internal meatus, and can usually be destroyed by fulguration through a cystoscope.

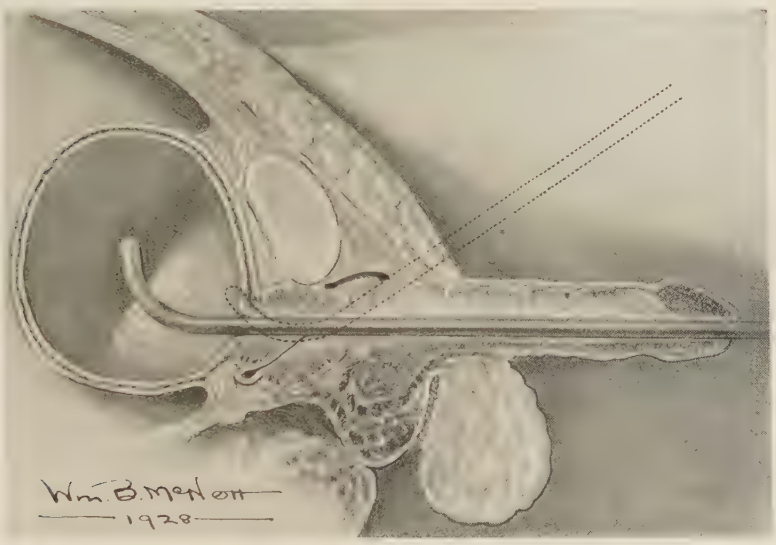


Fig. 1013.—Sound introduced into bladder. Dotted lines show position of the sound when pressure is released.

Hypertrophy of the Prostate.—The prostate consists of two primary lateral lobes, with a central indistinct median or third lobe posterior to the internal urethral orifice, which on enlargement forms a bar across the urethra, or acts as an obstructing ball-valve. The prostatic enlargement may be hard and fibromatous, or soft and adenomatous.

Etiology.—Obscure. After fifty, one-third of all men develop prostatic hypertrophy; in one-half of these, obstructive symptoms occur. In one-fifth of those developing obstructive symptoms, there is secondary carcinomatous change.

Pathology.—(1) Excess of fibrous tissue; (2) overgrowth of all the elements of the gland; (3) fibromyomatous tumors or fibroids which may form large growths; (4) fibro-adenomas cause the greatest enlargement. The urethra is elongated from 2 to 10 cm., the prostatic curve with the convexity backward is greatly increased, the prostatic urethra may become tortuous, the internal

meatus is elevated, distorted, or obstructed by the growth of the lateral lobes, or distended by enlargement of median lobe. The bladder shows primary hypertrophy, followed by dilatation, separation of muscular fasciculi, and trabeculation. The patient is unable to completely empty the bladder, the *residual urine* tending to increase progressively in amount. Secondary cystitis, hydronephrosis, pyonephrosis, or pyelonephritis are terminal conditions from back-pressure, distention, and infection.

Symptoms.—*First Stage.*—Decreasing force and size of the urinary stream, with absence of the normal parabolic curve. Delay in starting the flow. Fre-

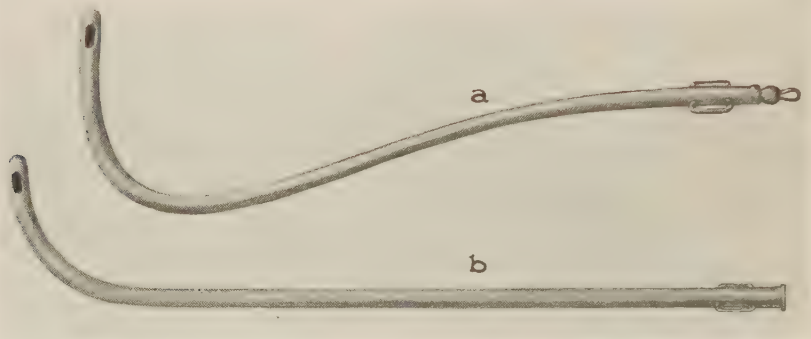


Fig. 1014.—Metal catheters: *a*, Normal curve; *b*, prostatic curve.

quent micturition, especially at night, at first from congestion and irritability of the vesical neck, later from retention.

Second Stage.—Retention of urine with from 30 to 300 c.c. of residual urine. Acute retention and incontinence of overflow often occurs, requiring the use of a catheter.

Third Stage.—Chronic cystitis with ammoniacal, decomposed urine, infection and degeneration of the kidneys.

Diagnosis.—(1) A firm, soft, or lobulated enlargement of the prostate is felt on rectal examination; (2) elongation of the prostatic urethra. The distance from the pubic arch to internal urethral orifice is more than 4 cm. A metallic

Fig. 1015.—Coude woven gum elastic catheter.

catheter with the normal curve may fail to enter the bladder, a coude catheter or a catheter with a long, large, prostatic curve being required. The cystoscope may show the intravesical enlargement.

Prognosis.—Hypertrophied prostate is a slowly progressive affection, if not relieved, often leading to renal infection and insufficiency in from five to fifteen years. The danger varies directly with the amount of residual urine.

If a large acute retention is suddenly relieved by catheterization, the sudden fall in back-pressure may be followed by edema and congestion of the bladder

and kidney, and uremia which may be fatal. The mortality of prostatectomy is 20 per cent., which may be reduced to 5 per cent. or less by proper pre- and post-operative treatment.

Preoperative Preparation for Prostatectomy.—The safety of prostatectomy depends largely upon the preoperative preparation of the patient. The general condition of the patient should be studied, the amount of residual urine determined, and the renal function estimated after the injection of phenolphthalein and indigo-carmin. A blood-chemistry examination, taken daily for one week and thereafter three times a week, is desirable. Blood-urea less than 20 mg. indicates a good risk; between 20 and 25 mg., fair; between 25 and 30 mg., questionable; and when over 30 mg., the prognosis is bad. If there is less than 60 per cent. of hemoglobin, the prognosis is poor; if below 40 per cent., very unfavorable. For retention, the bladder should be gradually decompressed by a catheter, filiform bougies, or a suprapubic puncture. After decompression, a retention catheter should be inserted, the bladder irrigated twice daily with a permanganate or boric solution, a thorough examination made of the urine, renal function, blood-chemistry, kidney-function; and the presence of early tabes, calculus, diverticula, or tumor eliminated. For the poor risk, water and other diuretics are freely used, followed later by a simple suprapubic cystostomy, the prostatectomy being done from two weeks to three months after beginning the treatment. Certain patients will not tolerate the indwelling catheter, on account of urethral irritation, hemorrhage, or previous urethral injury. For these patients with acute retention, an immediate cystostomy and gradual decompression of the bladder is used.

Operation.—In the first and second stage a prostatectomy by the suprapubic route is preferred. A suprapubic cystostomy is made, the index-finger introduced into internal meatus, pressed forward separating the capsule of the prostate, inside of which the finger is rotated, shelling the gland from its attachments. The procedure is favored by elevating the prostate and neck of the bladder, by a finger of the opposite hand introduced into the rectum. To prevent secondary hemorrhage, the cavity is closed by suture, packed with a long strip of iodoform gauze, or filled by a dilated Hagner bag. A large drainage-tube is fastened into the opening of the bladder, through which the end of the gauze drain and a small irrigator tube are brought out. A small drain is placed in the prevesical space, and the bladder and superficial soft tissues closed about the tube. Continuous irrigation with hot boric-acid solution is used for the first two days; to this, ½ per cent. of alum is added if there is oozing. The drain or Hagner tube is removed in forty-eight hours; the patient permitted out of bed on the third day and, unless there is active cystitis, the tube removed between the fifth and seventh days, and the opening in the bladder permitted to close spontaneously. If there is difficulty in voiding spontaneously, a full-sized catheter should be passed one or more times.

Perineal Prostatectomy.—While suprapubic prostatectomy is the operation of choice, the perineal operation is used if the bladder is much contracted, a violent cystitis present, or for small fibrous prostatic enlargements.

Operation.—A crescentic or inverted Y-incision is made anterior to rectum, through the triangular ligament and compressor urethra. The membranous urethra is opened, Young's prostatic retractor introduced through the opening into the bladder, and the prostate pulled down into the wound, the fibrous sheath incised on either side outside the seminal ducts, the gland enucleated, including the median lobe, and the cavities left packed with iodoform gauze around a tube introduced into the bladder. The perineal operation usually is more difficult than the suprapubic, gives better and more dependent drainage, is more frequently followed by a persistent sinus, impotence, and injury to the compressor urethræ, pelvic fascia, and rectum. It is the preferable operation where malignancy is suspected.

An obstructing *bar at the neck of the bladder* may be treated by the Bottani galvanic section, or Young's punch operation.

Prostatic calculi develop from a deposit of calcareous material in the dilated prostatic follicles.

Symptoms resemble those of a chronic prostatitis with vesical tenesmus; interference with urination, and grating may occur on the passage of a sound.

Occasionally the stone may be palpated by rectum, or demonstrated by roentgenogram.

Treatment.—Removal of the stone through a urethroscope, a median perineal incision, or with a prostatectomy.

Tuberculosis.—In the prostate, primary tuberculosis is very rare, and secondary tuberculosis usually involves the region of the ejaculatory duct, spreading by the posterior lobe to the lateral lobe, usually with a tuberculous vesiculitis. The condition is often unilateral. Secondary periprostatic induration and abscess formation often occur, with rupture through the perineum or rectum, and fistula formation. An extensive operation may be required for the tuberculous fistula produced, with packing and free drainage.

Carcinoma of the prostate, in the early stages, gives the symptoms of a simple prostatic hypertrophy. Urinary obstruction occurs earlier, and hemorrhage (either spontaneous or after instrumentation) is more common, while pain is a more evident symptom. Early cystitis and a hard nodular growth felt through the rectum, which later becomes fixed and infiltrates, suggest the presence of malignancy.

Treatment.—Perineal prostatectomy is preferred, the gland is freely exposed, the membranous urethra divided, the prostate with its capsule removed from within the pelvic fascia, the bladder walls divided at the junction with the prostate. After the removal of the prostate, the bladder is sewn to urethra over a catheter. Young's boomerang needle is of advantage in the suturing. The entire prostate, seminal vesicles, and the anterior two-thirds of the trigone should be removed.

Palliative Treatment.—Suprapubic cystostomy and anodyne suppositories. Radium and Roentgen radiation are rarely of permanent value, and often increase the pain.

Seminal Vesicles.—Acute vesiculitis (*Spermatocystitis*) may be acute, usually due to the gonococcus; or chronic, due to the gonococcus or tubercle bacillus. Acute vesiculitis occurs as a complication of acute urethritis. There is cessation of discharge, fever, tenderness and pain above Poupart's ligament, vesical and rectal tenesmus, pollakiuria, dysuria, and recurrent painful erections, especially during sleep. On rectal examination the vesicles are found distended, tender, and pulsating. An abscess usually forms which discharges into the urethra, or more rarely into the rectum or through the perineum.

Treatment.—Complete rest in bed, milk diet, suppositories containing opium, belladonna and ichthyol, hot compresses to the perineum, and hot enemas.

Chronic vesiculitis may or may not follow an acute infection. The vesicles become distended, the walls thickened and lined by hemorrhagic granulations. There is pain after exertion or jar, after sexual excitement, or the passage of instruments, with pain, weight, and discomfort in the perineum, penis, testicles, scrotum, loin, and thighs, a discharge of clear or turbid fluid from the urethra at stool, and mental apprehension. By rectal examination the distended tender seminal vesicles are felt, and a mucopurulent or blood-stained fluid may be expressed by stripping.

Treatment.—Emptying the vesicles by massage or stripping every five to

ten days. The use of an appropriate vaccine. Suppositories containing ichthyol and calomel.

Calculi.—At times, faceted calculi of phosphate of lime are present in the vesicles and cause a chronic vesiculitis. The stones may give a shadow upon the roentgenogram, and should be removed.

Tuberculous vesiculitis is almost invariably associated with a tuberculous epididymitis, producing a painless, firm, irregular or nodular enlargement. In 75 per cent. there is a preceding renal tuberculosis. There is little tenderness, and rarely a tuberculous abscess forms and produces a chronic sinus or fistula to the perineum or rectum.

Treatment is that of the associated tuberculous condition, with the use of tuberculin, and suppositories containing guaiacol, ichthyol, and iodoform. Radical excision is rarely advisable.

Vesiculotomy, vesiculectomy, (*incision* or *excision of the seminal vesicles*) is performed through an incision in the perineum, as for perineal prostatectomy. Much mental disturbance may follow the changes in sexual function produced by these operations.

PENIS

Congenital Anomalies.—Phimosis: A. Congenital. The child is born with long narrow prepuce with minute orifice, obstructing the urinary flow.

Results.—(1) Local irritation; (2) dilatation of the urethra, bladder, ureters, kidneys; (3) cystitis; (4) vesical calculus; (5) from straining—hernia, prolapsus ani, hemorrhoids.

B. Acquired occurs in aged men, from cicatricial contraction, or is secondary to inflammatory or malignant lesions.

Results.—(1) Balanoposthitis; (2) paraphimosis; (3) rupture of the frenum; (4) susceptibility to venereal disease, and (5) epithelioma of penis.

Treatment.—(1) Dorsal slit, the prepuce being divided on its dorsal surface, is used when a severe inflammatory disease (as chancroid or gonorrhea) is associated. (2) Circumcision: The prepuce and its lining mucosa are amputated on a line about 4 mm. below the corona glandis, and the edges united by suture. A circumcision may be complicated from the removal of an excess of skin, removal of too little skin, injury to the glans, secondary phagedenic or other form of infection.

Paraphimosis is due to constriction behind the glans, from retraction of a prepuce with a small opening. Secondary pain, swelling, edema, and at times ulceration or gangrene may follow.

Treatment.—(1) Reduction by compression of the glans, and manipulation; (2) dorsal incision freely dividing the constricting edge of prepuce or, if there is no associated infection, circumcision.

Atresia, stricture, or **stenosis of meatus** is treated by meatotomy. A blunt pointed knife is introduced through the meatus, and an incision made through to the frenulum, the parts being separated or dilated daily until healing has occurred.

Congenital stricture or **occlusion** occurs in the outer part of the fossa navicularis, and in the membranous urethra. The strictured area should be divided or dilated. Membranous septa are perforated and dilated. If the urethra is

absent, a posterior urethrotomy or suprapubic cystostomy should be done, followed later by the formation of new urethra.

Epispadias.—The open urethra forms a groove on the dorsum of the penis. It may be partial or complete, and associated with exstrophy of the bladder.

Treatment.—Closure of the groove by plastic operation.

Hypospadias.—A congenital defect of the floor of the urethra is much more common than epispadias.

Varieties.—1. *Balanic:* The under surface of the glans is grooved, the urethral opening lying just proximal to the glans.

2. *Penile.*—The under surface of the penis is cleft.

3. *Perineal.* -The scrotum being cleft, the urethral orifice is on the perineum, the penis is deformed and rudimentary. The child may be considered to be female, and the cleft scrotum to be the vagina. The testicles can usually be felt laterally, or may be retained in the inguinal canals or abdomen. Incontinence, which is present in complete forms of epispadias, is not present with hypospadias.

Operation.—1. A *plastic operation* to lengthen and contour the penis should precede the correction of the hypospadias.

2. *Balanic Hypospadias.*—Beck's Operation: The end of the urethra is dissected free, the glans centrally perforated, and the urethral tube pulled through and sutured to the margin of the skin of the glans.

3. *Penile, Scrotal, or Perineal Hypospadias.*—Forms of plastic closure usually fail, the implantation of epithelium-lined tubes is far more successful. The penis is tunneled through the corpus spongiosum, from the glans to the false opening, by a tenotome or trocar. Into this canal a catheter is sutured, covered, epithelial surface in, by a rectangular Thiersch graft taken from the thigh. To protect the graft, the urine is diverted by a second indwelling catheter, brought out through a perineal urethrotomy or a suprapubic cystostomy opening. The catheter holding the graft is removed in from seven to ten days, the indwelling catheter after two weeks, and the new canal dilated by sounds after the third week. Instead of Thiersch's grafts, McGuire and others have successfully implanted the appendix or its mucous lining to serve as a urethra.

Double penis is very rare.

Torsion of the Penis.—In epispadias the penis is frequently twisted.

Dislocation, Subluxation of the Penis.—Rarely, the organ is separated from its cutaneous coverings, and lies under the skin of the scrotum or groin.

"Fracture of the penis" is a rupture of the corpora cavernosa from sudden flexion of the erect organ. There is pain, swelling, ecchymosis, thrombosis of the venous sinuses, and often persistent priapism.

Treatment.—Rest in bed. Iced compresses for the first forty-eight hours, followed later by ichthyol or yellow oxid-of-mercury ointment. For extensive hemorrhagic effusions incision into the corpora cavernosa is desirable.

Wounds may be accidental, deliberate, or mutilative. Avulsion can be produced during erection. Strangulation by a metal ring, elastic band, cord, may result in necrosis and gangrené. The band should promptly be removed. The removal may be difficult, on account of the constricting object being deeply embedded in the swollen tissues.

Priapism is a form of continuous erection without sexual desire.

Etiology.—(1) Rupture of vessels of the corpora cavernosa, with extravasation of blood and thrombosis; (2) irritation from phimosis, balanoposthitis, prostatitis, or (especially in children) stone in the bladder; (3) leukemia; (4) injury or disease of the cervical spinal cord.

Treatment.—In injury with blood extravasation and thrombosis—(1) incisions into the corpora cavernosa. The power of erection is permanently lost, if there is obliteration of the vascular sinuses; (2) removal of the cause; (3) sedatives, such as bromids, hyoscyamus; (4) for disease of the spinal cord no treatment is required.

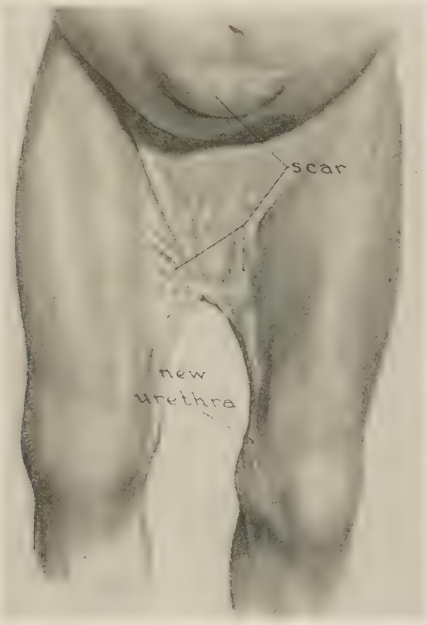


Fig. 1016.—Deforming scar in a Chinese boy from a burn of the fourth degree from ignited clothing. The thighs had been held flexed on the abdomen by the dense scar which is here shown after division. The external genitals are entirely covered and the urinary opening is just above the left medial condyle. The external genitals were later dissected out and found to be intact (Dr. B. M. Harding).

Balanoposthitis (*balanitis, inflammation of the glans*) is usually associated with inflammation of the prepuce (*posthitis*). The condition is favored by phimosis, local irritation, foreign bodies, by venereal diseases as chancroid, gonorrhea, and syphilis, and by diabetes.

Symptoms.—Marked local edema, purulent discharge, secondary ulceration of the glans or prepuce, and inguinal adenopathy.

Treatment.—Retraction of foreskin, frequent irrigation with antiseptic solutions, treatment of the underlying infection. A dorsal slit or circumcision may be required to permit satisfactory access to the area of infection.

Preputial calculi consist of uric acid, urates or phosphates, and occur with marked degrees of phimosis, either forming under the prepuce or being caught

in passing from the bladder. Balanoposthitis is produced with irritation and puriform discharge, the stones may be felt on palpation.

Herpetic Eruption.—Herpetic eruptions are frequent upon the prepuce and glans, beginning as clear vesicles showing a concentric arrangement, are painful, may become confluent, and tend to recur in crops.

Treatment.—Local application of lead-water or aluminum acetate solution.

Fibrous cavernositis, a chronic induration of the penis, occurs in patients over fifty with a flat, nodular, or cord-like deposit of fibrous tissue in the superficial part of the corpus cavernosum, usually near the midline on the dorsum. Separate nodules may be present, and ossification is occasionally seen. The induration may be due to traumatism, urethritis, or gummatous infiltration, and tends to produce a curvature toward the sound side, with pain on erection.

Treatment.—Mercurial inunctions and the administration of iodids should be tried.

Moist gangrene of the penis may follow paraphimosis, phagedenic chancre, chancroids, wounds, urinary infiltration, and eruptive fevers, especially typhoid and smallpox. The treatment depends largely upon the underlying condition. Non-irritating, moist antiseptic dressings are desirable.

Tuberculosis of the penis is rare and may appear as a papule, granuloma, or ulcer, with or without an associated tuberculous fistula. The treatment is similar to that for superficial tuberculosis elsewhere upon the body.

Tumors of the penis include sebaceous cysts, horns springing from ruptured sebaceous cysts, venereal warts, or papillomas of the prepuce or glans. Rarely, varices, endothelioma, sarcoma, and teratoma occur in the corpora.

Treatment.—(1) Correction of any urethral discharge, local cleanliness, calomel and bismuth dusting-powder for veneral warts; (2) excision or destruction by cautery or high-frequency current or amputation for tumors of the penis.

Epithelioma of the penis occurs in men over forty, usually with phimosis. It is relatively infrequent in Hebrews. An ulcer, wart, or fissure may precede the growth of the tumor. It usually begins along the corona glandis or the deep surface of the prepuce. A cauliflower-like mass of bleeding warts with indurated base or a deep ulcer with indurated base and edges develops, and may remain concealed by a phimosis. The carcinoma at times causes: (1) Diffuse solid edema of the penis; (2) a slough through the prepuce or urethra, with a urinary fistula; (3) secondary enlargement of inguinal glands with (at times) suppuration.

Diagnosis from papilloma, chancre, and tertiary syphilitic lesions is made by the characteristic ulcer, the peripheral induration, and the biopsy.

Treatment.—(1) In the early stage, amputation through the penis, the end of the divided urethra being sutured to the skin; (2) if the disease is extensive, amputation of the entire penis, including the crura close to the pubic bone and the inguinal lymphatic glands *en masse*, is indicated. The end of the urethra is sutured to the perineal skin. Excision of the scrotum is at times also required.

TESTES

Congenital Abnormalities of the Testes.—(1) Polyorchidism, more than two testes; (2) anorchidism, absence of testes; (3) monorchidism, one testis; all are rare.

Retained Testes (Undescended Testes).—A common condition, in which the testicles remain in the abdomen or inguinal canal. The testes may be: (1) *Abdominal*, attached to the posterior abdominal wall; (2) *iliac*, near the abdominal inguinal ring; (3) *inguinal*, in the inguinal canal. The scrotum is small and empty. The testes are soft, small, and usually there is aspermia and sterility, spermogenesis not occurring when the testicle is maintained at the higher temperature present within the abdomen. If in the inguinal canal, hernia usually coexists. Atrophy of the testicle, torsion, gangrene, orchitis, hydrocele, hematocele, and especially malignant disease may involve the retained testis.

Diagnosis from hernia and hydrocele of the cord is made by the character of the mass, and by the absence of the testes from the scrotum.

Treatment.—A truss should not be worn. Early operation is indicated to prevent degeneration of the testicle. The operation is similar to that for inguinal hernia, the testis being exposed, liberated, and placed in the scrotum. Reposition of the testicle in the scrotum is prevented by the shortness of spermatic vein rather than the vas. If necessary, a sufficient number of veins should be divided to permit the testicle to be brought to the bottom of the scrotum, to which it may be sutured. If many vessels are divided, the testicle may undergo degeneration or atrophy. The inguinal canal is finally carefully closed, as in a herniorrhaphy (*Bevan's operation*).

Ectopia Testis.—Rarely the testicle is guided by strands of the gubernaculum to an abnormal position outside the scrotum. The ectopia is usually *perineal*, or near the anterior superior spine of the pubis (*crural*).

Diagnosis is made by the absence of the testicle from the scrotum, and the presence of an oval body giving the testicular sensation on pressure in the abnormal position.

Treatment.—Incision and replacement of the testicle, or excision (castration).

Torsion of spermatic cord results from rotation of the testis, and produces strangulation of the spermatic vessels, with marked swelling and ecchymosis of the epididymis and, at times, necrosis and gangrene of the testicle.

Symptoms.—Acute sickening pain, with marked swelling of the testicle, epididymis, and cord. Vomiting and collapse may follow.

Diagnosis is to be made from strangulated hernia. The epididymis is found anterior to the testicle, and the inguinal canal empty.

Treatment.—Castration (replacement is rarely feasible).

Varicocele.—A varicose condition of spermatic veins usually occurs on the left side, and has been ascribed to lower position of the left testis, and the emptying of left spermatic vein into the renal vein instead of the vena cava.

Symptoms.—A mass of veins, like a bag of worms, is felt in the scrotum. The veins are empty when the patient lies down, but enlarge on standing, coughing, or straining. The testicle may be small, soft, and atrophic. Large varicoceles are often without subjective symptoms; while small varicoceles are found in neurotic men, who complain of a sense of dragging and weight in the

scrotum, backache, inability to concentrate, nervousness, and a multitude of other symptoms.

Treatment.—No treatment except the wearing of a suspensory bandage is usually required. If the symptoms are marked, one-third or one-fourth of the veins may be resected between double ligatures for a distance of 3 or 4 cm., and the stumps tied together to elevate the testicle if it is very low. If over one-third of the veins are ligated, secondary swelling with necrosis or atrophy of the testicle may follow.

Hydrocele.—A collection of serous fluid in the tunica vaginalis propria.

Varieties.—(1) *Vaginal*, into the tunica vaginalis; (2) *congenital*, into the open funicular and vaginal process; with a free communication with the abdominal cavity, the fluid passing into the abdomen on recumbency; (3) *infantile*, involving the vaginal and funicular process; the latter being closed at the in-

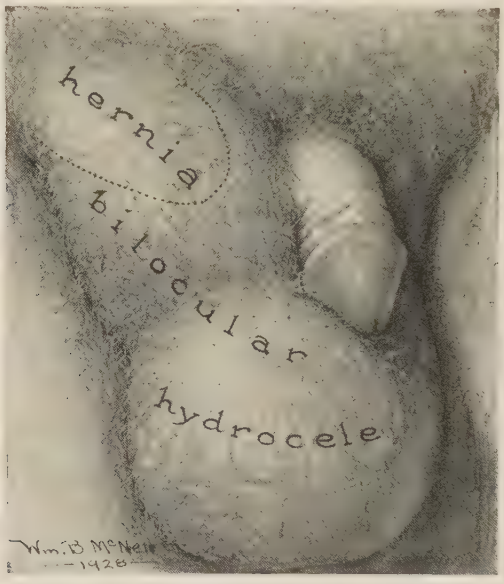


Fig. 1017.—Bilocular hydrocele associated with an inguinal hernia. (Patient of Dr. S. Leon Gans.)

ternal ring; (4) *bilocular*, in a bilocular funicular sac; (5) *acquired*—primary (without apparent cause) into the tunica vaginalis; or secondary, acute or chronic, from disease or injury of the testicle, epididymis, or cord.

Encysted hydrocele of the cord in an unobliterated part of the funicular process, shut off from the peritoneum and vaginal process.

Funicular hydrocele occurs in the patent funicular process, and may be *congenital*, when it communicates with the peritoneum; or *infantile*, when it is shut off from the peritoneal cavity.

Diffuse hydrocele of the cord is a condition of lymphatic edema.

Hydrocele of the round ligament (*hydrocele of the canal of Nuck*) may be unilocular or bilocular, and occurs chiefly in young women.

Hydrocele of the Testis and Epididymis: (1) Encysted hydrocele of the epididymis is characterized by dilatation of the spermatic duct; (2) encysted

hydrocele of the testis—the fluid lies beneath the tunica albuginea; (3) hydrocele of a hernial sac in infancy forms a congenital hydrocele; in adults it may arise in a hernial sac, after its contents have been reduced.

Primary Chronic Vaginal Hydrocele.—The tunica vaginalis is distended from unknown cause by a clear straw-colored fluid, forming a mass from the size of an egg to the size of a cocoanut. The fluid nearly surrounds the testicle, which lies at the back and lower part of the swelling. The sac is tense, translucent, projects from the body, and does not enter the inguinal canal. In old hydroceles the tunica vaginalis may become thickened, fibrous, cartilaginous, calcified, or warty and papillomatous. The translucency is impaired by hemorrhage, thickening of the tunica vaginalis, and adhesions. The mass is dull on percussion, without an impulse on coughing, and is bilateral in 20 per cent. It should be differentiated from hernia. A hematocele is harder, heavier, less elastic, not translucent, follows injury, and is associated with superficial ecchymosis and enlargement of the testis and epididymis.

A chronic vaginal hydrocele usually occurs in middle-aged or elderly men. A hydrocele of the cord occurs in infancy and childhood, and the mass in the inguinal canal is moved by traction on the scrotum and cord, and shows limitations above and below.

Treatment of Hydrocele.—1. *Palliative:* Aspiration by a small trocar or hollow needle, which is passed from the front upward and backward to avoid the testicle. Recurrence necessitates aspiration every two or three months.

2. *Injection treatment* aims to destroy the secreting endothelial lining by irritation. (a) Injection after aspiration, of 2 c.c. each of pure carbolic acid and glycerin or, better, irrigation of the sac with sterile water through two small trocars until the returning fluid no longer reacts for albumin. The sac is then emptied and 5 minims of liquefied phenol injected. (b) Aspiration of sac and injection of 1 mg. of tuberculin, which is repeated in four days if sufficient reaction does not occur. A violent secondary inflammation may follow. (c) Injection of from 1 to 8 c.c. of tincture of iodin.

The injection treatment is painful, with the exception of the injection of small quantities of phenol, produces marked reaction, and frequently fails.

3. *Bottle operation* is the preferred treatment. A 2- or 4-cm. incision is made through the scrotum in the line of skin cleavage, the tunica vaginalis opened and evacuated, the testicle pulled through the opening so that it lies between the tunica vaginalis and the cremasteric fasciæ when the skin is closed by interrupted horsehair sutures. This operation is usually successful, and gives fewer recurrences than resection, excision, or inversion of the sac.

Infantile Hydrocele of the Cord.—The swelling is above and distinct from the testes, more or less reducible; the congenital form is reducible into the peritoneum, the infantile form partially reducible. Often the sac does not refill after aspiration.

Encysted Form: Locular enlargement at one part of the cord. The condition may be multiple. It is more common on the right side.

Treatment.—Aspiration or excision.

Encysted hydrocele of the epididymis (*spermatocele*) with dilatation of one of the ducts or fetal tubes at the head of the epididymis is painful and,

on aspiration, altered spermatic fluid (alkaline, opaque, and milky, with living or degenerated spermatozoa) is found.

Encysted hydrocele of the testes occurs beneath the tunica albuginea, is usually small and, if troublesome, should be treated by resection or excision.

Hematocele.—Accumulation of blood in the tunica vaginalis or cord: (1) *Vaginal* (most common); (2) diffuse, in the cord; (3) *encysted*, in testis, epididymis, or cord. Arises from bleeding in a corresponding hydrocele.

Etiology.—Contusion, puncture or sudden wrench of the body, or malignant disease. In the early stages the sac contains fluid or clotted blood, later laminated clots with cartilage or calcareous material, and degeneration of the testicle occurs. A rapidly developing, oval, non-translucent tumor enveloping the testis and epididymis, solid, doughy, ecchymotic. In recent cases cord is not thickened. The size may remain stationary.

To differentiate a hematoma from sarcoma, gumma, or other new-growth, operative exploration is often required. A non-traumatic hemorrhage into the testis is usually due to malignant disease.

Vasostomy has been used to determine the patency and to treat infections of the vas and ejaculatory ducts. A hypodermic needle is introduced in the vas (exposed by a short incision in the upper part of the scrotum), and a colored solution or bland antiseptic injected. If there is no obstruction, an injected 1 : 1000 methylene-blue solution in normal saline will escape from a catheter introduced to the prostatic urethra. Bland antiseptics may lead to irritation and obliteration of the vas (Lespinasse and Brams).

Epididymectomy is used largely for well-localized tuberculosis.

Epididymovasostomy advocated for sterility (obstructive gonorrheal aspermia) by Edward Martin, consists of an anastomosis of the vas and globus major. The tunica vaginalis is opened and a 5 to 12 mm. lateral incision made in the vas. The vas is tested for patency by probing with a strand of silkworm-gut or by injection. If patent a small ellipse of the head of the epididymus is resected, and if the secretion shows living spermatozoa a side-to-side anastomosis is made. If the first operation fails, it may be repeated, using different tubules. Employing fine silver wire sutures, Young had 38 per cent. of cures.

Treatment.—In acute cases rest, elevation, aspiration. In chronic cases incision, bottle operation; resection of thickened, degenerated, vaginal process; or castration.

Orchitis occurs in about one-fifth of the cases of mumps, involving first the stroma, with secondary invasion and destruction of the tubules. The epididymis is swollen, congested, and a small inflammatory hydrocele may occur. Secondary atrophy of the testicle follows in about one-third of the patients. Orchitis also occurs in smallpox, typhoid, glanders, in blood-stream infection (as septicemia), in tonsillitis, furunculosis, osteomyelitis, endocarditis, glanders, and influenza, Malta fever, and leprosy. Suppuration of the epididymis is infrequent.

Tuberculous epididymitis is usually preceded by tuberculosis of the kidney and seminal vesicles, infection being along the vas. It involves first the globus minor, then the body of the epididymis, and finally the testicle. Tuberculosis beginning in the body of the testis is seen in children under two years, sometimes in tuberculous peritonitis as an infection extending along the vaginal process. The urethra is resistent to the infection. In 75 per cent. the opposite epididymis is involved within two years. Urogenital tuberculosis is most common between the ages of twenty-five and forty-five. Secondary sinuses often form.

Treatment.—Epididymectomy, epididymovasectomy, or castration if the associated disease is not so far advanced as to preclude operation.

Syphilis of the Testicle.—**Gummatous orchitis** occurs in the tertiary stage of syphilis, with the production of a diffuse interstitial orchitis or the development of a gumma. It may be inherited or acquired, usually involves a single testicle which slowly and painlessly enlarges until it is several times its normal size, with retention of the normal shape and smooth surface. At times hard nodules are present. Testis is hard, woody, without pain, tenderness, or testicular sense. The epididymis is not invaded. The vas, seminal vesicles, and prostate are free from disease; a hydrocele is often associated. The gumma may finally discharge through the scrotum.

Treatment.—Active antisyphilitic treatment, associated with the local use of mercurial ointment. If the testis has become necrotic and fungous, castration is indicated.

Inherited syphilis *(cirrhosis)* is more common, the testicle being enlarged, very hard, painless, with a hydrocele of moderate size.

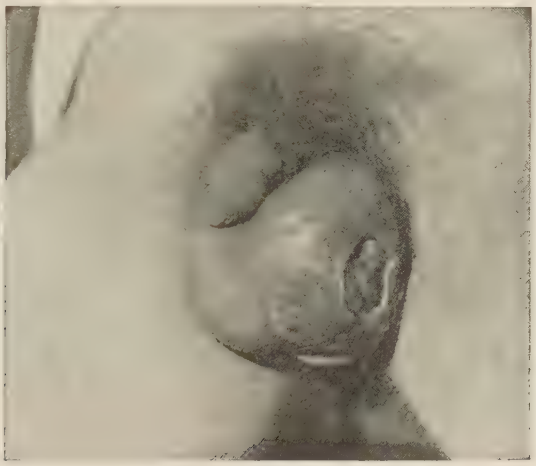


Fig. 1018.—Typical gumma of left testis (fungus testis) often confused with sarcoma, teratoma, or tuberculosis. Early there is a *billiard-ball* testis, slowly developing enlargement without marked symptoms, except dragging or aching. Insensitive to pressure, often associated with hydrocele, usually unilateral. The epididymis usually escapes. In tuberculosis the testis is involved secondary to the epididymis (Stokes).

Syphilitic epididymitis occurs in the secondary stage three or four months after infection, involves the globus major, running a subacute or chronic course, and rapidly disappearing with treatment.

Tumors of the testis are usually unilateral and form $\frac{1}{2}$ per cent. of all tumors; 12 per cent. occur in undescended testis (Hinman), especially in the abdominal testis. The average age is thirty-five years, tumors of the testicle being rare under eighteen and over fifty years. A few occur in infancy.

Benign Tumors.—*Fibroma* and *adenoma* are very rare. Non-malignant *hyperplasia* of the interstitial cells has been reported. *Leiomyoma* rarely occurs in the epididymis.

Malignant tumors are chiefly *teratoma* or *seminoma* (Chevassu).

Sarcoma of the testis occasionally develops in the testicle under the age of ten, especially with an undescended testis. There is progressive enlargement, often following injury, without pain or tenderness, with loss of testicular sense, uniform shape. With perforation of the tunica albuginea the mass becomes irregular, bosselated, and hemorrhage within the tunica albuginea or tunica vaginalis causes sudden increase in size. There is early involvement of the iliac and lumbar glands, and lymphatics. In neglected cases, secondary ulceration through the skin and the formation of a large fungous testis occurs, with the production of large masses of foul-smelling necrotic tissue.

Prognosis.—Simple castrastion cures 15 per cent.; radical excision, 30 per cent. (Young).

Treatment.—Castration with removal of the inguinal, iliac, and lumbar glands.

1. *Seminomas* are tumors composed of one specific type of cell, and distend but do not penetrate the tunica albuginea. Section shows grayish-white, smooth,

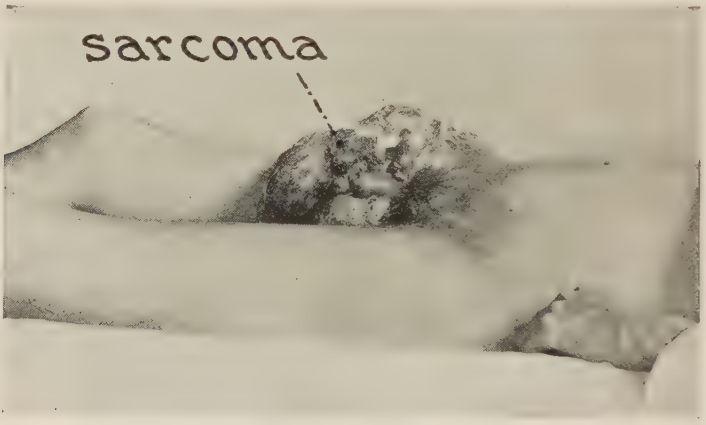


Fig. 1019.—Fungating sarcoma of the right testicle.

opaque areas of necrosis and hemorrhage, without cysts, beginning near the rete testis with displacement of the testicular tissue. A moderate hydrocele is usually associated. The tumor consists of acini with lymphocytic infiltration, and occasionally bits of cartilage.

2. *Embryomas* (*teratomas, mixed tumors*) contain multiple cysts and areas of hemorrhage and necrosis, forming a soft semiliquid tumor with destruction or displacement of the testis. The tunica albuginea is not penetrated early. The vas is normal or slightly indurated. The tumor is composed of blood-vessels, muscle, cartilage, myxomatous tissue, rarely bone, epithelium, gland-like areas, and is rarely benign.

3. *Chorio-epithelioma* (*syncytioma, chorioma*), resembling that seen in the uterus, occasionally occurs. Metastasis to regional lymph-nodes appears early; secondary metastasis to the opposite testicle is rare.

Symptoms.—Progressive, rapid, painless enlargement; sense of weight or dragging, with loss of testicular sense.

Prognosis.—Death usually occurs within three years from the progressive growth of the metastatic tumors. Multiple malignant nodules in the lung are very suggestive of a malignant tumor of the testicle.

Treatment.—Immediate radical excision, including testicle, epididymis, vas, scrotum, spermatic vessels, and retroperitoneal lymph-nodes, from the brim of the pelvis to the renal vessels, with adjacent connective tissue. For advanced or recurrent disease, the growth may be temporarily checked by radiation.

No instances of melanoma have been reported.

Tumors of the Scrotum.—Mucoid and dermal cysts are chiefly found along the median raphé. Small cysts of the sebaceous glands are not infrequent. Lipoma, lymphangioma, hemangioma are rare.

Epithelioma of the scrotum, chimney sweep's cancer, is favored by the local irritation of soot. *Paraffin cancer* occurs in workers whose clothing becomes impregnated with paraffin.

Mulespinner's cancer is a form of cancer of the scrotum occurring in operatives in cotton mills, especially in England.

Epithelioma begins as a black or wart-like papillomatous mass, or as a cauliflower growth or ulcer. Metastasis occurs chiefly to the inguinal lymph-nodes, rarely in the iliac nodes. Treatment is radical excision, with castration and removal of the regional lymph-nodes.

Melanoma, sarcoma, and teratoma are rare tumors of the scrotum.

CHAPTER LVIII

THE EXTREMITIES

Congenital defects of the extremities may be due to intra-uterine amputation, as from pressure of amniotic bands or hereditary defect in the germ

Fig. 1020.—Ectrodactylism. Congenital partial agenesis of the hands with absence of third and fourth fingers.

plasm. The defects include: (1) Absence of one or more extremities, except for a rudimentary stump (*amelus* or *ectromelus*). The distal part of the extremity

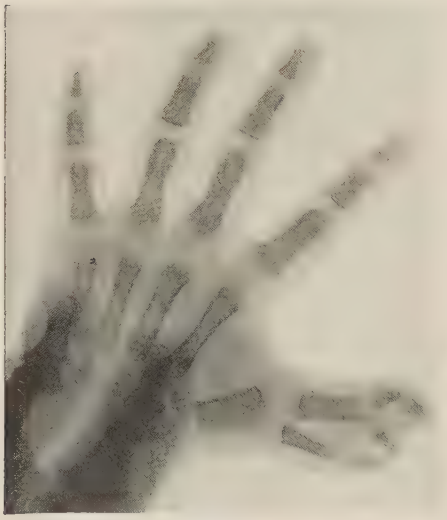


Fig. 1021.—Double fused thumb with four terminal phalanges.

Fig. 1022.—Roentgenogram showing supernumerary thumb with two terminal phalanges.

may be lacking or rudimentary (*hemimelus*). (2) Absence of one (*monobrachius*) or both of the upper extremities (*abrachius*), or of the lower extremity

(*apus*). (3) Absence or rudimentary condition of the bones of either the upper or lower extremity, the foot or hand articulating directly with the trunk (*phocomelus*). (4) Abnormally short extremity (*peromelus*). (5) Insufficient size of the extremity (*micromelus*). *Microbrachius* refers to the upper extremity, and *micropus* to the lower. (6) Short or diminutive fingers or toes (*perodactylism*). (7) Fusion of fingers or toes (*syndactylism*, *web-fingers* or *web-toes*). (8) Shortening of the whole hand (*brachydactylism*), or of one or more fingers (*brachyphalangism*). (9) Absence of one or more fingers (*ectrodactylism*), or of all fingers (*adactylism*).

Treatment.—A plastic operation or fitted prosthesis to improve the appearance and function of the defective part. Neoplasty or occasionally amputation may be desirable.

Polydactylism.—Supernumerary fingers or toes are more common than defective digits, are often hereditary, and should be amputated in childhood.

Macrodactylism.—Congenital hypertrophy of one or more fingers or toes is not unusual and may require resection, amputation or plastic operation.

UPPER EXTREMITY

Congenital Anomalies.—The radius, clavicle, one or more bones of the hand may be defective or absent. Congenital defects of the ulna are rare.

Partial defects of the radius may be associated, with absence of the radiocarpal bones, the muscles of the radial half of the forearm and those of thumb. Rarely, absence of the lower end of the biceps or triceps is noted, or webbing of the skin and fascia at the elbow preventing complete extension.

Congenital Elevation of the Scapula (Sprengel's Deformity, Sprengel's Shoulder—1891).—The scapula is cephalad and slightly rotated, its lower angle being nearer to the vertebral column than is normal. There is shortening or ossification of the suprascapular muscles with bony, cartilaginous, or fibrous connections between the scapula and the cervical vertebræ, and usually, coexisting defects of ribs, vertebræ, muscles, and other parts (club-foot or spina bifida). Scoliosis and asymmetry of the head are associated in a majority of the cases. The deformity usually is unilateral. If bilateral, there is difficulty in raising the arms to the horizontal plane.

Diagnosis.—The Roentgen appearance is characteristic. The scapula is elevated, and the upper part hooks forward.

Prognosis.—Unfavorable without, only fair with operation.

Treatment.—Mechanical measures are useless. The contracted muscles should be divided in early life. The scapula is exposed by an incision running parallel with and slightly above its spine. The muscles, fibrous, or bony attachments are divided, the scapula drawn to a position as nearly normal as possible, and held by suture and bandage. Suture of the scapula to the ribs may cause a temporary brachial paralysis.

Scapula alata (*winged scapula, angel-wing deformity*) is a rather rare condition due to paralysis of muscles supplied by the long thoracic nerve (fifth and sixth cervical roots) characterized by: (1) Winging or protrusion of the posterior border and angle of the scapula; (2) limitation of abduction of the arm which cannot be raised above the level of the shoulder; (3) absence of anterior

fixation of the scapula. Forward pushing movements of the arm are markedly weakened; (4) restriction of forced inspiratory movements. The scapula cannot be properly fixed and the important action of the serratus anterior as an accessory respiratory muscle is lost.

The predominant condition is the paralysis of the serratus anterior which permits the scapula to slip backward and mediad, especially at its lower border.

Etiology.—Involvement of the long thoracic nerve from: (1) Weights carried upon the shoulder; (2) neuritis and poliomyelitis; (3) injury during the course of operation; (4) invasion or pressure by malignant or other tumors.

Diagnosis.—Winged scapula due to malnutrition or wasting disease (as in starvation, tuberculosis, carcinoma, typhoid fever, or caused by central forms of paralysis) should not be included under the term "scapula alata." In lesions of the spinal cord the adjacent muscles are also weakened, as the trapezius muscle (supplied by accessory and third and fourth cervical nerves), the latissimus dorsi muscle (the thoracodorsal nerve from sixth, seventh, eighth cervical), and the rhomboidei (the dorsal scapular nerve, from fifth cervical).

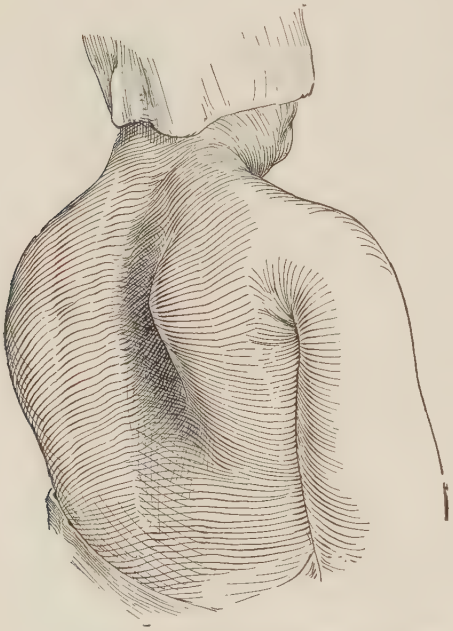


Fig. 1023.—Right scapula alata from resection of the long thoracic nerve in a radical amputation of the breast for carcinoma.

Treatment.—(1) Massage, electricity, and the wearing of a supporting pad; (2) liberation or suture of the compressed or divided long thoracic nerve; (3) suture of a flap of the subscapularis muscle to the thoracic wall (Babcock). Suture of the pectoralis major to the lateral edge of scapula or subscapularis muscle.

Synostosis (*bony fusion*) usually unites the radius and ulna. Congenital dislocation is most common at the shoulder or elbow. At the elbow congenital dislocations involve the upper end of the radius, or less frequently there is dislocation of both bones of the forearm.

On attempts at reduction the radius is usually found to be longer than the ulna.

Cubitus varus or **valgus** (an increase or decrease in the normal carrying angle of the forearm) may be congenital, hereditary, or acquired from unequal growth, due to premature ossification (rickets), or injury of the epiphysis of one of the bones of the forearm.

The higher grades of deformity may be treated by an osteotomy, wedge-shaped resection of the lower end of the humerus, or by resection of the abnormally long radius or ulna.

Supernumerary bones are less frequent in the wrist-joint than the ankle,

and include: The *os triangularis*, which may be mistaken for fracture of the styloid process of the ulna; the *os epipyramis*, suggesting a fractured lunate (semilunar); a *double navicular bone*, suggesting fracture; an *os paratrapezium*, *os versalium*, or *os ulnare externum*.

Club-hand is rare, and may be dorsal, palmar, radial, or ulnar in its deviation. Palmar deviation is most common; radiopalmar or cubitopalmar deviations occur.

Radiopalmar club-hand results from congenital absence or abnormal development of the radius. The lower extremity of the ulna projects, and the metacarpal bone of the thumb may be absent. Hypoplasia of the radius is less common than aplasia.

Manus valga or **Madelung's deformity of wrist** (Dupuytren, 1839; Madelung, 1878) is characterized by a lateral bowing of the lower end of the radius,

Fig. 1024.—Agnew's operation for syndactylism. The web is split and the posterior triangular dorsal flap formed.

deflecting the hand toward the radial side. The end of the ulna forms a prominence on the dorsal side of the wrist, the hand being carried ventrad on the articular surface of the radius. The anterior posterior diameter of the hand is increased. There is a compensatory dislocation of the ulnocuneiform articulation.

Etiology.—(1) Hereditary influence is present in about 10 per cent. (2) Occupational strain, injury, or rickets may favor the deformity, which develops between the ages of eight and twenty-five, and especially in girls about puberty (80 per cent.). The condition is due to abnormality of the lower radial epiphysis, aided by the pull of the flexor muscles.

Symptoms.—Early there is pain and aching in the wrist, followed by increasing deformity; the pain subsiding when the deformity has fully developed.

Extension, dorsiflexion, circumduction are limited, while volar flexion is normal or increased. The condition usually progresses for about three years until ossification is complete.

Treatment.—(1) Massage, support by leather cuff; (2) osteotomy of the lower end of the radius with correction of the deformity, and fixation by splint until firm bony union has occurred.

Cleft hand (*bifurcation of the hand, lobster-claw hand, main fourche*), an absence of the middle digits with or without the associated metacarpals, is often bilateral. The fingers may be abnormally large, long, fused, or deficient in number. A plastic operation may be desirable to improve the function or appearance of the part.

Congenital hypertrophy (*partial giantism*) chiefly involves the middle finger, next in frequency the index-finger, and next the thumb.

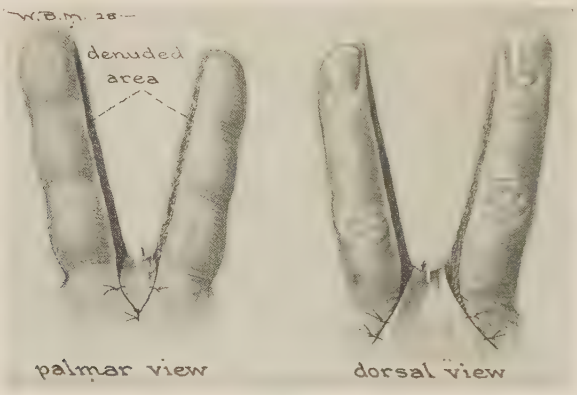


Fig. 1025.—Agnew's operation for syndactylism. The web is divided and recurrence prevented by the interposition of the V-shaped dorsal flap. The denuded area is covered by the ingrowth of epithelium or by skin-grafting.

The enlargement involves the digit and its contained bones, and frequently the associated metacarpal or metatarsal bones. Resection or amputation may improve the function or appearance of the hand.

Syndactylism.—The partial or complete fusion of two or more fingers; is usually congenital, but occasionally results from burns or other injury. If the fingers are separated by a simple incision, the web tends to re-form from the apex of the denuded cleft. To prevent this a flap of skin (*Agnew's operation*) or skin-graft should be applied to the apex of the cleft. The web may be divided and all denuded surfaces covered by Thiersch's grafts, accurately held in place by a stent of wax or dental modeling-compound.

Didot's plasty is made by raising dorsal and ventral flaps having their bases on opposite sides of the fingers, the fused fingers being separated, and each flap wrapped around the finger to which it is attached. Gangrene has frequently followed the operation due to the division of nutrient vessels in raising the flaps, and the method should not be used when the amount of soft tissue is limited.

Pieri's Operation.—The fingers are separated by an incision of zigzag type. This operation is useful in overcoming contraction from a web of skin.

Symphallangism.—A rare deformity with partial or complete fusion of the interphalangeal joints, either bony or tendinous. The condition may be bilateral and symmetrical. If the absence of a joint is troublesome, partial amputation or an arthroplasty may be attempted in later life.

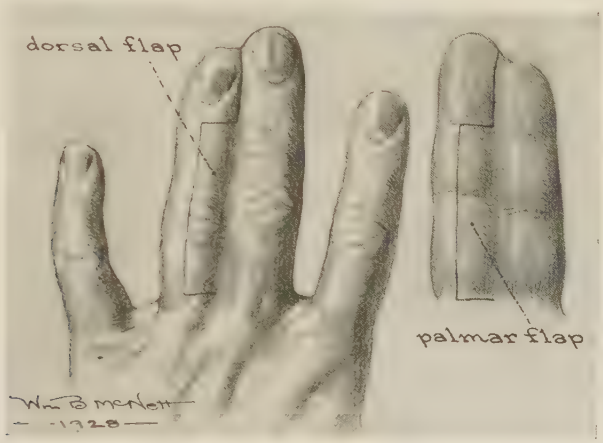


Fig. 1026.—Syndactylism. Didot's operation, lines of the posterior and anterior flaps.

Ectrodactylism.—A congenital absence of one or more of the fingers and associated metacarpals; may be marginal, central, or total (all the fingers are missing).

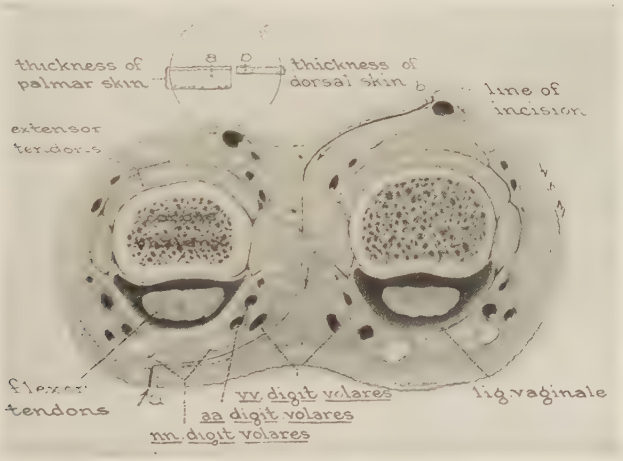


Fig. 1027.—Syndactylism. Didot's incision, showing the proximity of the digital arteries to the incision. Gangrene of the finger has repeatedly followed this operation.

Congenital contracture of fingers usually involves the little finger, the first phalanx being hyperextended, the second and third flexed, being opposite to Dupuytren's contraction. The middle processes of the palmar fascia are shortened instead of the lateral digital ones.

Treatment.—Forcible extension, graduated elastic traction, or operative

subcutaneous division of the contracted digital prolongations of the palmar fascia.

Ischemic contracture (*Volkmann's contracture, ischemic myositis*—Stromeyer, 1838; Volkmann, 1869) is due to muscular degeneration, fibrosis, and atrophy following injury or the application of a tight splint, bandage or Esmarch's band; or to embolism, thrombosis, or ligation of the main artery of the limb. It chiefly affects the forearm, but also occurs in the leg.

Pathology.—As a rule there is venous stasis, and the exposed extremity swells and becomes cyanotic. Secondary fibrous degeneration of muscles occurs and the flexor and pronator muscles on the anterior arm become atrophic, fibrous, anemic, friable.

The nerves and vessels are enveloped in a fibrous mass, the bones soften or atrophy from the primary ischemia, hemorrhagic infiltration, and disuse. Joint-movements are limited by the muscular contracture or fibrous ankylosis.

Fig. 1028.—Pieri's Z-plasty to lengthen a web of skin. Lines of incision forming anterior and posterior flaps, *a*, *b*.

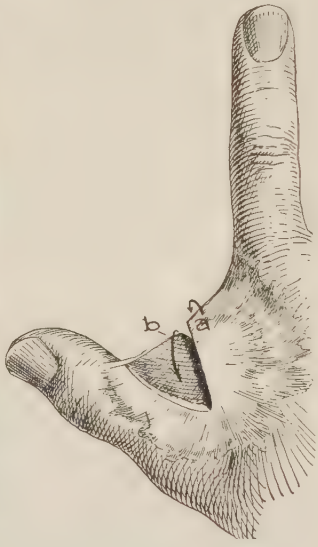


Fig. 1029.—Pieri's Z-plasty; *a*, *b*, the flaps formed.

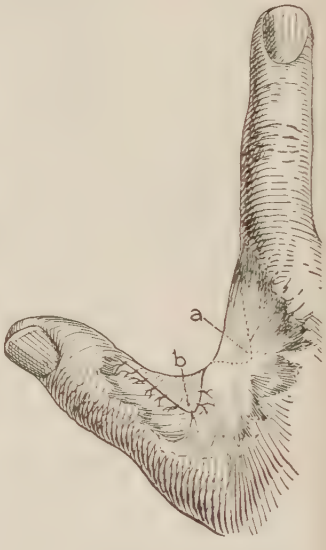


Fig. 1030.—Pieri's Z-plasty: *a*, *b*, flaps sutured.

Symptoms.—The contracture usually occurs between the ages of three and fifteen years, after the application of splints or bandages for injury. There is great pain, the parts exposed below the bandage swell, and pressure- or splint-sores may form with degeneration and fibrosis of the deeper tissues. The interphalangeal joints of the fingers are flexed, the metacarpophalangeal joints being straight. The forearm is pronated or slightly flexed, the wrist may be strongly flexed, or movable so that the fingers may be straight on flexing the wrist. The cicatricial contraction involving the tendons differs from paralytic contractures, which yield under an anesthetic, and form the deformity due to ankylosis of the fingers or wrist with rigidity.

Treatment.—Prophylactic: (1) Allowance for secondary swelling in applying bandages after injuries or operations upon the arm or leg. Avoidance of a primary Jones position. (2) Loosening of splints and bandages at onset of secondary pain or swelling. If the skin-tension is marked and evidently producing ischemia, a free longitudinal incision through the skin and subcutaneous fascia should be made before secondary necrosis occurs. After the deformity has developed, the graduated extension of the contracted parts may be attempted by a banjo or similar splint. Hot baths, massage, and baking are of value. If the disability is marked, operative liberation of the contracted muscles, tendons, and skin, tendon transplantation, neurolysis, or the shortening of forearm by resection of radius and ulna should be considered.

Fig. 1031.—Dupuytren's contraction. Position of the Papal benediction.

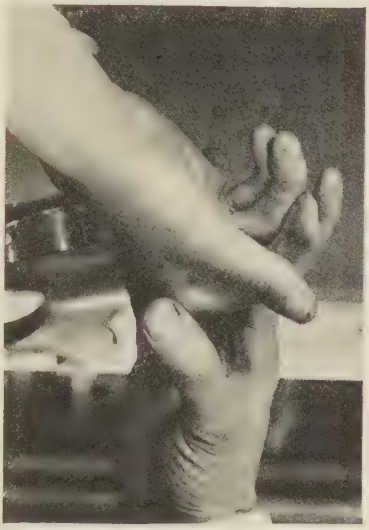


Fig. 1032.—Contraction of the fingers from a deep burn of the palm. The deformity was overcome by grafting a double pedicled flap from the abdominal wall to the palm.

Dupuytren's contracture (Dupuytren, 1831) consists of a thickening and contracture of the digital processes of the palmar fascia, the fingers being gradually flexed upon the palm. The tendons are not involved. It affects adults, chiefly males and after middle life. The contraction is favored by rheumatism, gout, and recurrent trauma of the palm. Usually it involves the left hand, but the contraction in the right often follows. It consists of a chronic inflammatory fibrosis of palmar fascia with secondary contracture and adhesion to the skin, involving chiefly the ring- and little fingers. It may spread to other fingers. An elevated fold of skin covers the thickened fascia, and extends along the palm. It should be differentiated from contraction of the flexor tendons, which is relaxed on flexing the wrist, while in Dupuytren's contracture the flexion persists.

Treatment.—In the early stages, elastic extension, manipulation, massage, radiation, and injections of fibrolysin may be tried. Usually these forms of treatment are ineffective, and the contracted palmar fascia must be divided or excised

to give relief. The operation consists of: (1) Multiple subcutaneous divisions of the palmar fascia with a small tenotome; (2) exposure and excision of the thickened fascia (Kocher, 1887) through a straight, curved, or flap incision. At times nearly all of the palmar fascia requires removal, and transplantation of fat or skin may be necessary.

Baseball finger is produced by impact of a baseball on the tip of palmar surface of the finger, with sprain, dislocation, or fissured fracture of the terminal phalanx. A Roentgen examination should be made and, after reduction, the finger bandaged over a large palmar cylinder (roller bandage) for two weeks, after which graduated massage is used.

Mallet-finger (*drop-finger*) is a persistent flexion of the terminal phalanx, due to a violent hyperflexion of the distal phalanx with rupture, overstretching, or tearing of the extensor tendon. It often follows impact from a baseball.

Treatment.—(1) Early—by splint in hyperextension; (2) in persistent cases, open incision, and suture of tendon to the periosteum.

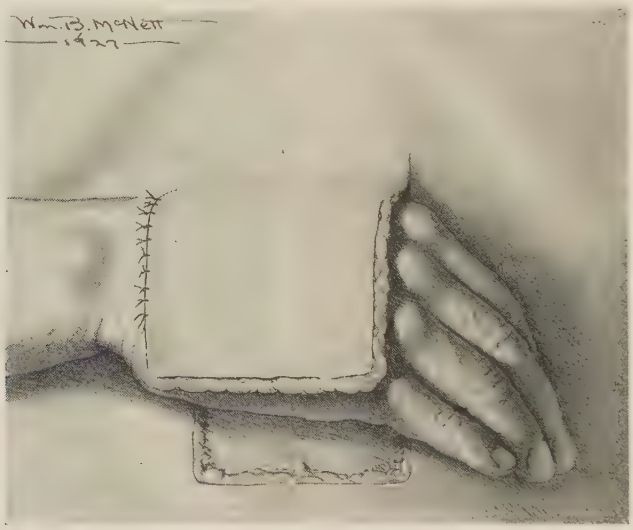


Fig. 1033. Use of a single pedicled flap from the abdomen to cover a defect on the dorsum of the hand.

Snap-finger (Trigger- or Spring-finger).—An acquired deformity involving one or more fingers, movement being interrupted, and the finger then flying open or shut without muscular control. It involves, in order of frequency, the middle finger, the ring-finger, the thumb, the index-finger.

Etiology.—The erratic movement is due to: (1) A growth on the tendon (90 per cent.), especially a localized fibroid thickening (*tendon-callus*) which may be felt over the metacarpophalangeal joint, from contusion or partial tear of the tendon. The thickened portion catches in the tendon sheath, or where the deep tendon perforates the superficial. (2) Contraction of the tendon sheath; (3) pressure of a sesamoid bone, ganglion, or (4) alteration in the joint-surfaces from injury or disease.

Treatment in severe cases is operative exposure, usually under local anes-

thesia, with correction of the causal condition such as the contouring of a thickened tendon or irregular articular surface, or division of a constricting tendon-sheath, excision of a ganglion, sesamoid bone, or other non-essential structure causing pressure.

Dislocation of the Extensor Tendons of the Fingers.—Rarely, the two halves are displaced laterally, interfering with the beginning of extension.

Treatment consists in suturing the halves of the tendon together.

Foreign Bodies in the Palm.—Broken needles, especially, are very difficult to find, and should accurately be localized by the roentgenogram and (in relation to movements) under a fluoroscope, noting if the foreign body moves with a tendon or muscle. Needles may migrate and, therefore, should be removed promptly. To prevent migration a splint should be applied after the Roentgen examination.

Fig. 1034.—Illustrating the communication of the synovial sheaths of little finger and thumb with the synovial sacs of the palm.

Felon (Whitlow).—An abscess involving the palmar surface of the finger. The infection so often cripples the hand that immediate treatment with early incision, rest in bed, and a copious wet dressing enveloping and immobilizing the hand are indicated in all but the most superficial types.

1. **Subcuticular felon,** the formation of a pustule under the epidermis. The raised epidermis should be freely incised or resected.

2. **Subcutaneous felon** usually occurs over the distal phalanx following a contusion or wound, with swelling, tenderness, severe throbbing pain, increased by dependency. Fluctuation is difficult to detect through the dense palmar fat, and the infection may extend to the bone or, less frequently, to the tendon sheath. Painless felons occur in syringomyelia.

Treatment.—A free median incision should be made of ample length, owing to the tendency of the subcutaneous fat-pad to interfere with drainage. The lateral incisions which have been advocated may damage the digital vessels and nerves, producing a permanent disagreeable paresthesia. Vaselined gauze-drains are preferred to tubes, to avoid pressure-necrosis.

3. **Subperiosteal bone felon** may be primary, or secondary to the subcutaneous variety, or to a paronychia from the relationship of the base of the nail to the bone.

A free vertical median incision should be made to the periosteum, necrotic bone should not be removed until it has become completely separated, and a curet or other agent that may damage the periosteum should not be used. Despite the necrosis of the phalanx, amputation should not be done unless there is destruction of the joints, as regeneration of bone is usual. A copious wet antiseptic dressing should envelop the entire hand and the patient kept at rest during the active stage of the infection.

4. **Synovial thecal felon** (*suppurative tenosynovitis*) may follow the subcutaneous or osseous type, or result from staphylococcic or streptococcic infection from a puncture or wound. The infection extends along the synovial sheath to its termination. With the ring- and middle finger this is opposite to the neck of the corresponding metacarpal bone. From the thumb, the lateral or radial palmar sac associated with the flexor pollicis longus may be entered. From the little finger, the medial or ulnar palmar sac—which widens in the palm, and envelops the tendons of the ring-, middle, and index-finger—is often involved. From a palmar sac extension may occur under the annular ligament of the wrist into the forearm or to the carpal articulation. The finger is moderately swollen, especially on the volar side, there is great pain on flexion or other movement, with heat, edema, and tenderness.

Treatment.—Immediate median longitudinal incision, not crossing the creases over the joints. The tendon or the mesotendon (vinculum) should not be injured. Moist, hot, antiseptic fomentations and complete rest of the hand and body should be enforced. If the operation is delayed the tendon undergoes necrosis, and in three or four weeks is expelled. With suppuration of the radial sac from thecitis of the thumb, swelling and tenderness are present along the medial side of the thenar muscles, from above the annular ligament to the radial side of the palmaris longus. To evacuate the pus one incision is made over the proximal phalanx of the thumb, and a second 2- or 3-cm. incision from the base of the thumb on a line to the ulnar styloid. The short flexor of the thumb is cut, the sac identified by moving the thumb, and the thenar branches of the median nerve avoided in the upper part of the wound. A third incision, running from the crease of the wrist upward for 4 cm., is made above the annular ligament parallel to and just within the line of the radial vessels, which are retracted. In extreme cases the annular ligament is freely divided.

Palmar cellulitis causes marked swelling on the dorsum of the hand from the resistance of palmar fascia anteriorly; the tenderness is anterior. The finger motion is not restricted. The pus accumulates in: (1) The thenar space under the thenar eminence, deep in the palm just above the adductor pollicis (transversus); (2) in the hypothenar space beneath the hypothenar muscles.

1. The *thenar space*—often involved from infection of the thumb, index-finger, or occasionally the ring-finger—is opened by a dorsal incision parallel to the metacarpal bone of the index-finger, at the radial side of the bellies of the interossei. A hemostat or scissors is pushed between the metacarpal bones into the abscess, which is evacuated by Hilton's method. This avoids a scar on the palm or injury to the palmar arch. A palmar incision, made between the tendons of the index- and middle fingers, may be necessary when the original infection enters through the palm.

2. Abscess of the *hypothenar space* is relatively infrequent, and is opened by an incision parallel to and on the ulnar side of the fifth metacarpal bone.

3. The *midpalmar space* suppurates from infection of the ring- or middle finger. It is limited by the middle metacarpal on the radial side, and overlapped

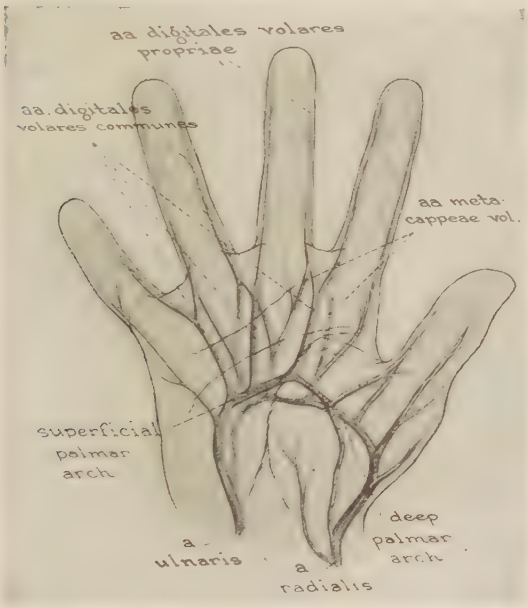


Fig. 1035.—The arteries of the hand.

Fig. 1036.—Chancre of index-finger of a physician following a slight laceration sustained in doing a tonsillectomy.

by the ulnar bursa on the ulnar side (Kanavel). It may be drained from the dorsum of the hand through the lumbrical space between the ring- and middle fingers, or by a palmar incision between the digital pads of these fingers peripheral to the superficial palmar arch.

For **septic arthritis** of the wrist and deep cellulitis of the forearm, lateral incisions are used. Through-and-through drainage under the muscles and nerves may be necessary, and a destructive arthritis may even necessitate a resection of the wrist. Copious wet dressings should be applied and the hand and forearm fixed upon a splint.

Tuberculosis affects the hands in the form of *verruca necrogenica* (see page 467) or *spina ventosa* (see page 237).

Syphilis.—*Chancre* of the finger is not uncommon, especially in physicians, emphasizing that rubber gloves should be worn for operations, surgical dress-

ings, and during the digital examination of sores and mucous surfaces. Hereditary and secondary eruptions often appear upon the palms, and *syphilitic spina ventosa* involves the phalanges.

LOWER EXTREMITY

Bony Defects.—The fibula may be partially or more often completely absent. Usually there is an associated marked anterior angulation of the tibia at the junction of the middle and lower third, and absence of one or more toes, the foot being in an equinus position. Less frequently there is hypoplasia of the tibia or femur. The patella may be absent, or the femur double.

The foot is not only subject to the common club-foot but also to defects similar to those involving the hand, such as: Ectrodactylism, aphalangism, hemimelia, syndactylism, symphallangism, polydactylism, hyperphalangism, chondrodystrophy, brachydactylism, fusion of tarsal bones, macrodactylism.

Pes gigas (*congenital hypertrophy of the foot*) usually involves the three medial toes and metatarsal bones, with a painless hyperplasia of osseous and soft tissues.

Treatment.—Bony resection or amputation is used to overcome the deformity and improve locomotion after the age of three.

Jumping, springing, or **snapping hip** (*Hanche à resòrt*) is characterized by a sudden snap or "cloc" over the great trochanter, usually on rotation of the

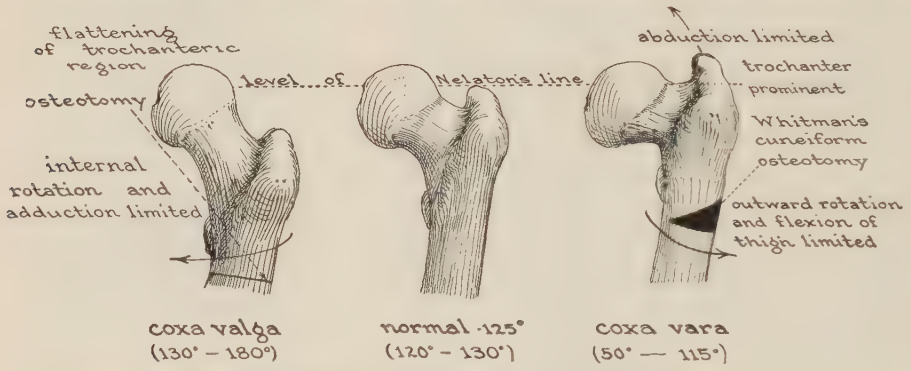


Fig. 1037.—Clinical characteristics of coxa valga and coxa vara.

slightly flexed and adducted thigh. It occurs in children and young adults, from the slipping of the fascia lata or the anterior border of the glutæus maximus over the great trochanter. It may be congenital or acquired, bilateral or unilateral. If congenital, it is not associated with pain or limp, and is due to a low insertion of the glutæus maximus. If acquired from the tearing of the upper attachment of the glutæus maximus from the linea aspera (allowing the anterior border of the muscle with its fascia to slip suddenly over the trochanter), there may be pain and lameness and, to avoid the cloc, the patient keeps the hip extended or walks with the body inclined toward the well side. There is secondary scoliosis, adduction of the affected limb, elevation of the anterior superior spine on the same side, and apparent projection of the trochanter.

Diagnosis.—A cord-like band may be felt slipping upon the trochanter. This is to be differentiated from slipping due to subluxation of the hip, inflamed or absent bursa, or an osteoma.

Treatment.—If there is serious disability or pain, the anterior edge of the glutæus maximus may be sutured to the periosteum over the trochanter, and to the femoral aponeurosis and vastus externus (Bayer Heully).

Coxa Vara.—A downward bending of the neck of the femur so that the angle formed with the shaft of the femur is 115 degrees or less. The normal angle is 130 degrees, at birth 160 degrees. In later life the angle becomes more acute.

Etiology.—(1) Boys between twelve and eighteen years; (2) injury in infancy or childhood, with fracture of the neck or separation of the epiphysis; (3) rickets, producing bilateral coxa vara; (4) softening of the bone in adults; (5) senility, with osteo-arthritis and atrophy and weakness of the bone.

Symptoms.—(1) Slight limp with, at times, aching and weakness of leg; (2) elevation, and prominence of trochanter on flexing the thigh; (3) limitation of abduction, increased adduction; (4) eversion in the traumatic form; (5) limitation of rotation; (6) scissors deformity in the extreme bilateral form.

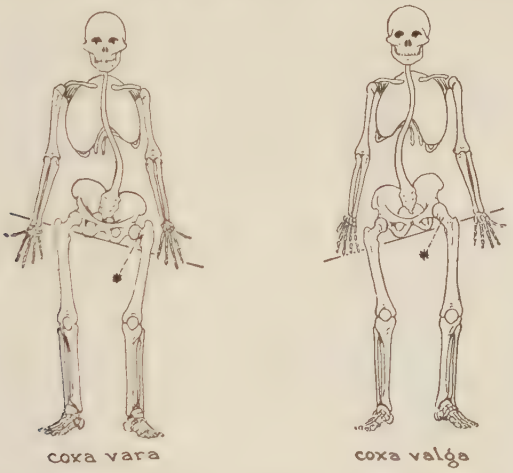


Fig. 1038.—Tilting of the pelvis and secondary spinal curves from coxa vara and coxa valga. In the first the femur is shortened; in the second, lengthened.

Treatment.—(1) High heel for shortening; (2) fixation by a case in an overcorrected position after forcible abduction for recent cases; (3) wedge-shaped (Whitman's operation) or linear subtrochanteric osteotomy, with fixation in extreme abduction.

Coxa Valga.—An increase in the angle between the neck and shaft of the femur so that it is greater than 130 degrees.

Etiology.—A wide femoral angle is rare (more common in boys), is usually unilateral, is chiefly due to lack of weight-bearing as in congenital dislocation of the hip, or is the result of an acquired dislocation, a hanging paralyzed limb as in infantile paralysis, a scoliosis, malunion after fracture, or rarely rickets.

Symptoms.—Limping toward the affected side, with a rolling gait. The trochanter is less prominent and, below Nélaton's line, abduction is increased and adduction diminished, often with outward rotation of lower extremity. The leg is lengthened by 2 or 3 cm.

Treatment.—Weight bearing, manipulation, high sole on normal side. Osteotomy through the trochanter is rarely required.

Osteochondritis coxæ (*osteochondritis deformans coxæ juvenilis; Legg's disease*, 1909; *Perthes-Calvé disease*, 1910) is characterized by flattening and irregularity of the head and neck of the femur, occurring in childhood without involvement of the acetabulum. It may be traumatic or inflammatory in origin. There is a limp and restricted abduction, but little pain. The trochanter is prominent and elevated.

Treatment.—Rest and support. The prognosis is good, the condition usually disappearing in two or three years.

Gluteal stabilization is used for extreme relaxation of the hip-joint. One half of the sacrospinalis (erector spinæ muscle) is split off, and, from the end of this muscular flap, Lange silk cords are carried through the greater trochanter, and the limb placed in adduction for three or four months. Thick fibroconnective tissue forms around the silk, producing heavy fibrous cords with a silk interior.

Genu valgum (*knock-knee*, *X-legs*) is an abnormal abduction of the leg, the feet being separated when the knees are together. An obliquity of the lower epiphysis of the femur and upper epiphysis of the tibia is often present.

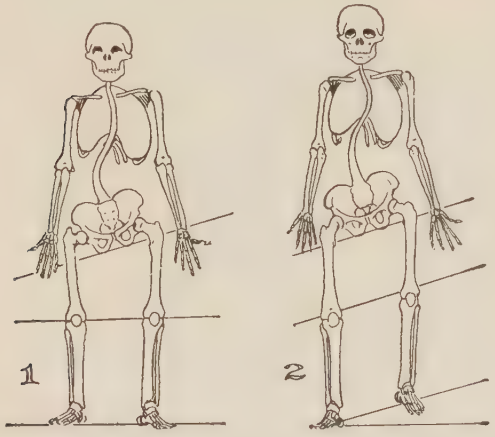


Fig. 1039.—1, Right coxa vara with shortening of the right leg. 2, Right coxa valga with lengthening of the right leg.

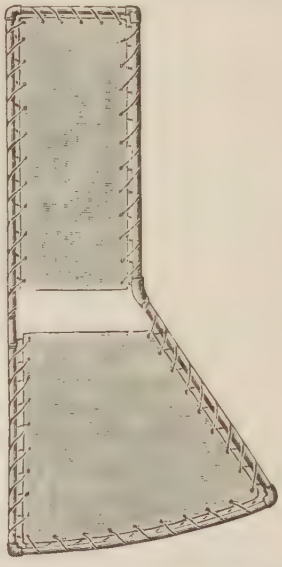


Fig. 1040.—Bradford frame modified for abduction.

Etiology.—(1) Rickets (*genu valgum rachiticum*); (2) inequality in ossification; (3) walking or standing with the legs rotated outward and abducted (*genu valgum staticum*); (4) trauma during the period of ossification; (5) soft and relaxed tissues; (6) paralysis or traumatism. Flat-foot may follow or cause knock-knee. Either the lower end of the femur or the upper end of the tibia is bent laterad, or the medial condyle of the femur and the medial condyle of the tibia are disproportionately developed. The medial lateral ligament is relaxed, and the medial tibial condyle can often be separated from the femur by abduction. The fibular collateral ligament, tibiofibular ligaments, and biceps are proportionately shortened. The patella is displaced laterally. In

extension, the line of the tibia lies lateral to that of the femur. The fibular collateral (external lateral ligament) is relaxed and shortened, the tibial collateral ligament lengthened. With slight flexion of the knee, the ankles usually may be brought together. The toes point laterad when standing, there is exaggerated external rotation of the leg and, when walking, the knees are kept slightly flexed. A bursa often forms at the medial side of the knees where they knock together. Knock-knee usually is bilateral, rarely is unilateral, or one leg may show genu valgum and the other genu varum. Scoliosis and flat-foot often coexist, and the pelvis is tilted in the unilateral cases.

Prognosis.—Under the age of six the legs tend to straighten, if abnormal weight-bearing is prevented.

Treatment.—1. Under the age of six, massage, manipulation, and the treatment for rickets. The medial side of the sole of the shoes should be thickened 3–5 mm., the child taught to stand and walk slightly "toeing in," and splints used during the period of rachitic softening of the bones.

2. Between the age of six and puberty, corrective braces and elevating the medial side of the shoes. The child should walk and stand without external rotation of the foot.

3. After puberty: (a) Osteotomy of the shaft of the femur (*Macewen's operation*). The bone is cut partly through and broken just above the condyles, the deformity corrected, and the leg put up in corrected position. (b) Osteotomy of the medial condyle (*Ogsten's operation*): The medial condyle is separated from the lateral by an oblique incision into the joint, the loose condyle with the tibia is then slid upward. There may result a secondary arthritis with adhesion. (c) Cuneiform osteotomy of the tibia: A wedge-shaped piece is cut from the shaft of the tibia on the medial side below the tubercle. This is the most accurate method.

Fig. 1041.—Bilateral talipes equina varus, genu recurvatum, and lumbar spina bifida.

Genu varum (*bow-leg*) is similar to, but the reverse of genu valgum; is much less common but due to similar causes. It may be anterior, posterior, or lateral. In the sabre deformity of syphilis there is hyperplasia, rather than a bending of the bone.

Posterior bow-leg or *genu recurvatum* is the reverse of anterior bow-leg.

Treatment follows the plan used for genu valgum with feeding, manipulations, and braces to the age of five or six, when osteotomy or osteoclasis of femur or tibia is resorted to. After the operation a case is left on for four to six weeks, the patient walking at the end of eight weeks.

Osteoclasis, or fracture of the bone by an osteoclast, cannot be used when the curve is near the joint or when the bone is very soft.

Rupture of plantaris (*tennis leg*) occurs during climbing, jumping, boxing, tennis playing, or other exercises, with pain in the calf of the leg, like the sting of a whip (*coup de fouep*), tenderness, swelling, later ecchymosis of the posterior surface of the leg from extravasation from the deep vessels.

Treatment.—Rest and bandage with the knee flexed and the heel raised. Walking upon the toes without support should be avoided for three or four weeks.

Pes valgus (*Volkmann's congenital deformity of the tibiotarsal joint, Volkmann's supramalleolar deformity*) is a lateral deviation of the foot, usually from lack of development of the lower end of the fibula and the talotibial (tibioastragalar) articulation. The entire foot is displaced laterally, with abnormal projection of the medial malleolus.

Treatment.—A supramalleolar osteotomy, a resection of the ankle or arthrodesis may be required.

Supernumerary bones of the foot are not uncommon and on the roentgenogram may be mistaken for bony fragments due to fracture. They include the: (1) *Os trigonum*, found at the base of the posterior surface of the talus, behind the medial or lateral tubercle; (2) *os tibiale externum*, found behind and below the tubercle of the navicular; (3) *os peroneale*, a sesamoid bone in the tendon of the peronæus longus at the anterior lateral extremity of the calcaneus; (4) *os vesalii*, found at the base of the fifth metatarsal bone; or rarely (5) *secondary os calcis*, at the superior anterior extremity of the calcaneus; (6) *intercuneiform bone*, lying between the first and second cuneiform bones; or (7) *intermetatarsal bone*, lying between the bases of the first and second metatarsal bones.

Supernumerary bones are found in about one-third of normal feet. Supernumerary bones, particularly the os trigonum, may be injured by sudden forced plantar flexion of the foot. The os tibiale externum may cause a sensitive swelling (especially in the treatment of flat-foot) necessitating removal.

Big Heel (Endemic Enlargement of Os Calcis).—A unilateral or bilateral enlargement of the heel, which begins with local pain, tenderness, fever, and bony enlargement, and chiefly involves the lateral posterior aspects of the calcaneus, with hyperostosis but without joint-involvement. The condition interferes with walking.

Treatment.—Drilling of the bone in one or more places or, if this fails, an osteotomy with removal of the excessive bone.

Contracted Tendo-calcaneus (Achillis).—*Pointed toe* occurs in talipes calcaneus; frequently from neglect to support the foot in fractures and inflammatory diseases of the leg, or as a result of reflex irritation. If organic the tendon should be stretched either by manipulation, elastic traction, or by the use of plaster (Aitken's method). Division of the tendo-calcaneus by subcutaneous tenotomy or tenoplasty may weaken the foot, and should be used only in extreme cases.

Erythromelalgia, intermittent claudication, and gangrene of the toes have been discussed (see pages 105, 107, 392).

Flat-foot (*pes planus, splay-foot*) is characterized by flattening of the arch, and tendency to pronation (*pes valgus*) and adduction of the foot. Flattening of the arch may be normal in certain individuals, especially in negroes, and cause

no symptoms. Flat-foot usually is bilateral, and is more common in males. It may be *acute*, *rigid*, or according to cause: (1) Congenital; (2) static; (3) traumatic; (4) paralytic; (5) rachitic; (6) arthritic; (7) gonorrheal; (8) tabetic. There is no normal type of foot; a high arch may be weak and painful, a flat arch strong and painless.

Etiology.—Foot strain due to: (1) Ill-fitting shoes or change in the type of shoes worn; (2) muscular and ligamentous insufficiency of support, from rapid growth, illness, or trauma; (3) excessive weight; (4) overuse of the feet.

Symptoms.—Fatigue on walking or standing, with pain in the foot from the stretching of the inferior calcaneonavicular and interosseus ligaments and compression of the bony arch. Frequently there is pain, cramps in the soles of the feet or calves of the legs, tenderness or synovitis of the knees, backache, pain

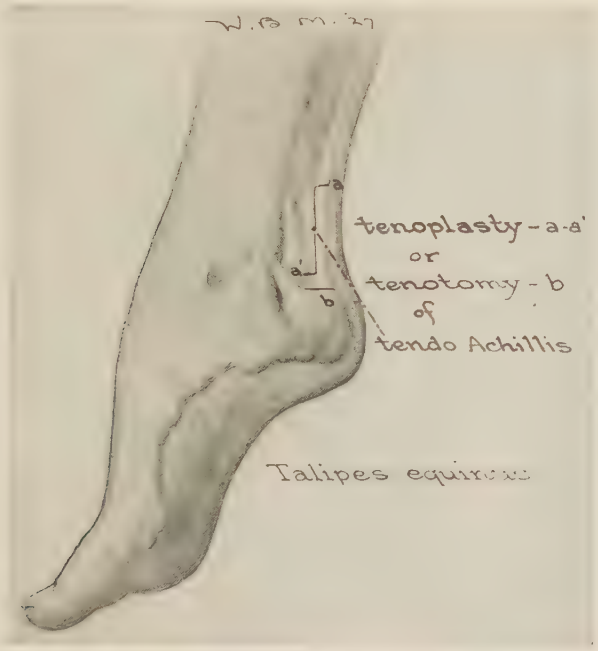


Fig. 1042.—Incisions in the tendo achillis in tenotomy and tenoplasty.

in the hips. The foot is long, broad, and spreads and everts on weight-bearing; the gait is slouching. Foot-prints show the depression of the medial border of the foot, roentgenograms the displacement of the bones of the foot.

Prophylaxis and General Treatment. 1. Well-fitted shoes of the orthopedic type, with flexible arches and straight insole.

2. Avoidance of external rotation or adduction of the foot in walking.

3. Daily exercises to strengthen the foot by: (a) Walking and rising on the balls of the toes; (b) rising and walking on the lateral edge of the foot; (c) walking with the toes turned in; (d) internal circumduction of the foot.

4. Maintenance of full nutrition.

5. Avoidance of prolonged standing or of weight bearing.

Degrees of Flat-foot.—First Degree: Arch is restored on removing weight of the body, or if the patient rises on toes. *Second Degree:* Arch may be restored by manipulation. *Third Degree:* Arch can only be restored under anesthesia. *Fourth Degree:* Arch can only be restored by operation.

1. **Acute Painful Flat-foot.**—May follow change to occupation involving foot strain, or early resumption of physical work after a relaxing illness, or an arthritis from gonorrhea or rheumatism. The foot becomes tender and swollen, and should be treated by rest, elevation, and support in a corrected position by a plaster case. Walking is resumed with local support after ten days, provided it is not painful.

2. **Rigid flat-foot,** in which the foot is flat, pronated, stiff and painful, may be congenital or follow acute flat-foot. Flexibility should be restored by thorough wrenching with the Thomas wrench under an anesthetic, after which

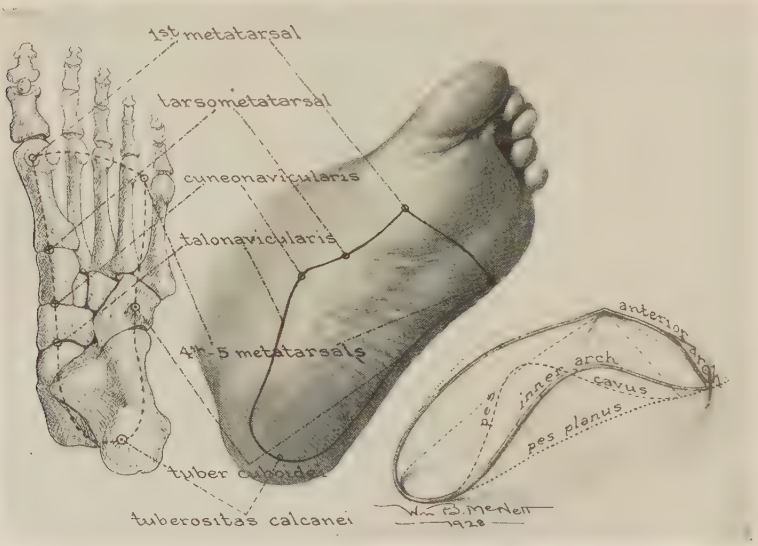


Fig. 1043.—The longitudinal and the anterior transverse arches of the foot and their relation to pes cavus and pes planus.

the foot should be treated as an acute flat-foot, and put up in fixation with the arch well molded, the foot at right angles to the leg, and the forefoot well adducted and inverted. Later the heel of the shoe should be raised on the inner side. A lateral iron may be necessary to maintain a correct position on weight bearing.

3. **Static** or **adolescent flat-foot** is a common form, occurring in growing children between the ages of fourteen and twenty. The treatment depends on the degree. In *young children*, flat-foot is usually associated with knock-knee or relaxed knees and is noticed as a deformity rather than as a disability. A shoe with a tilted heel and a carefully shaped pad to support the arch (which might otherwise become distorted during growth, owing to the tilted position) serves until the child is old enough to be taught correct standing and walking and to be aided by corrective exercises. Foot-plates and arch-

supporters should not be indiscriminately used. They are best made from a plaster cast of the foot, and should be accurately placed.

4. **Spasmodic flat-foot** with spasm of the peronei muscles may be treated by rest, hot fomentations, injections of 2 per cent. phenol into the involved muscles or peroneal nerve, or the wearing of a plaster case.

5. **Paralytic flat-foot** usually follows poliomyelitis. Braces, arch-supports, supporting (corset) shoes, or tenoplasty may suffice. Extreme types may require arthrodesis of the talus, navicular, and cuneiform bones (the incision being made on the medial side of the foot), or talusectomy (astragalectomy).

Talipes (*talus*, ankle; *pes*, foot) **or Club-foot.**—A deformity of the foot due to persistent and fixed abnormal relation of the foot to the ankle. Club-foot refers chiefly to congenital talipes equinovarus. A permanent abnormal deviation of the foot in the direction of extension is *talipes equinus*, in flexion *talipes calcaneus*, in abduction *talipes varus*, or in adduction *talipes valgus*.

Varieties.—A. The SIMPLE VARIETIES of distorted foot are: (1) *Talipes equinus*—the foot is plantar flexed or extended, and the patient walks upon the heads of the metatarsal bones. (2) *Talipes calcaneus*—the foot is dorsiflexed, the heel being prominent and bearing the weight in walking. The motion is sufficiently limited to interfere with function. (3) *Talipes varus*—

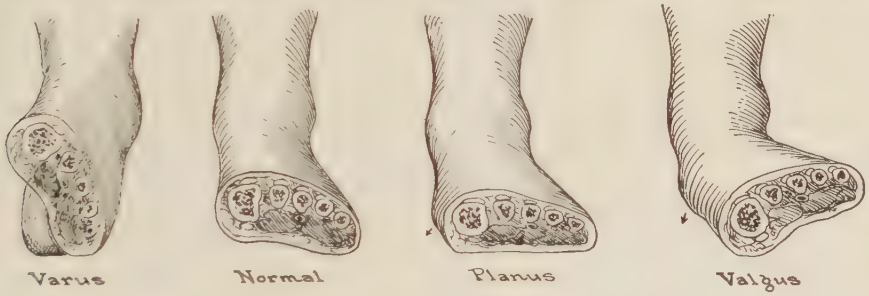


Fig. 1044.—Section of the normal foot in relation to pes varus, pes planus, and pes valgus.

inverted or adducted foot; a medial twist with inversion, the medial border of the sole is elevated, the lateral border is depressed, the patient tending to walk on the lateral edge of the foot. (4) *Talipes valgus*—everted or abducted foot; the sole is everted so that the patient walks upon the medial border of the foot, the center of the motion being at the mediotarsal and subtalar joints.

B. COMPOUND VARIETIES of talipes are more common than the simple type, and include: (1) *Talipes equinovarus*—extended and inverted foot. (2) *Talipes equinovalgus*—extended and everted foot. (3) *Talipes calcaneovarus*—a flexed and inverted foot. (4) *Talipes calcaneovalgus*—a flexed and everted foot.

The arch is usually increased in calcaneus and equinus, and diminished in valgus.

Pes cavus refers to an exaggerated arch to the foot; *pes planus*, to a flattened or lessened arch.

Etiology.—1. *Congenital talipes* includes: (a) Deformity with little change in the elements of the foot; (b) deformity with aplasia or hyperplasia of component parts of the foot or leg; (c) congenital paralytic talipes, as occurs in

forms of spina bifida. Congenital talipes may be due to the position of the feet and legs *in utero*, traction by the umbilical cord, pressure of amniotic bands, or the pressure of intra- or extra-uterine tumors. Harelip, exstrophy of the bladder, spina bifida, or other deformity may be associated. The condition is nearly twice as common in males as in females, and often is bilateral.

2. *Acquired talipes* usually is the result of paralysis, especially anterior poliomyelitis which unbalances the supporting elements of the foot. Usually it is unilateral, and occurs nearly equally often in the sexes. It may be due to: (1) Diseases of the nervous system (*paralytic* or *spastic talipes*); (2) injury or disease of the muscles, tendons, or bones; (3) contraction of a scar; (4) compensatory, static, or postural conditions. Talipes equinus and valgus are usually acquired. Talipes calcaneus may be either congenital or acquired.

Diagnosis.—In talipes equinus the patient walks on toes; in talipes calcaneus, on the heels; in talipes varus, on the fibular side of foot; in talipes valgus, on the tibial side of foot.

1. *Congenital club-foot* is usually bilateral, with little muscle wasting or impairment of electric reactions. There are creases in sole of foot, malformed bones and ligaments, and contracted muscles. The circulation is good, trophic changes are absent, and growth is not impaired.

2. *Acquired Club-foot.*—(a) Paralytic type is usually unilateral, follows infantile paralysis; the limb is atrophied, bluish, cold, clammy, with trophic lesions and wasting of muscles. The electric reactions are absent, the growth of bone retarded, manipulation restores the position of foot, there are no furrows in the flexures, and partial paralysis of the leg muscles exists. (b) Spastic type is unilateral or bilateral, with spasm or contraction of other parts, exaggerated reflexes, characteristic gait, contracted or (late) atrophied muscles, and evidence of spinal sclerosis or other disease of the nervous system.

Equinovarus forms three-fourths of the congenital cases of talipes, and about one-third of the acquired type. The foot is plantar flexed, inverted and adducted. In severe cases the sole points almost upward. The heel is small and elevated, the forefoot broad and twisted, the dorsum curved and prominent. The tibia and fibula may twist mediad, and the deformity cannot be corrected by manipulation. In adults, if untreated, a bursa forms over the cuboid, the calves are shrunken, the gait is inelastic. The patient is unsteady on his feet, and lifts one foot over the other in walking; callosities form on lateral borders of the feet. The displaced talus projects upon the lateral dorsal surface, the lateral malleolus is prominent, medial malleolus largely covered. The extensor and adductor muscles, tibialis anterior, tibialis posterior, gastrocnemius and soleus are shortened and strengthened; the apposing muscles are lengthened and atrophied. If the condition is not arrested in infancy, the patient may walk on the fibular side or even the dorsum of the foot. The legs are shrunken from disuse, and a callus develops over the calcaneocuboid articulation, with an underlying bursa. The foot is atrophied and small. Knock-knee may be associated.

Prognosis.—When corrected in infancy, the functional result is excellent; the functional restoration is less perfect when made in later life.

General Treatment.—Congenital Type: Treatment should be started as soon after birth as possible.

1. *Manipulation.*—Beginning three or four days after birth, the foot is gently untwisted, and the deformity corrected by the hand several times daily. By the second or third week, an attempt may be made to maintain the correction by the application of a roller bandage or adhesive plaster. If this is ineffective, the deformity is corrected and held by a light plaster-bandage, applied from the toes nearly to the knees. At the end of a week the plaster is removed, the part recorrected, and a second plaster-bandage applied. This is repeated weekly for four or five weeks, when the varus should be overcome, and plaster may be applied with the foot in a position to correct the equinus. After correction, the foot is held by plaster in extreme eversion and dorsal flexion for several weeks.

2. *Simple Splints and Braces.*—If these measures fail, forcible manual correction by a wrench or osteoclast under an anesthetic is desirable, the reduction being held by a light plaster-case, by splints or braces. If all these measures fail:

3. *Operations upon tendons and bones* may be tried: Tenotomy of the tendo calcaneus, with division of the posterior ligaments uniting the tibia with the base of the talus. External support should be continued until the child has learned to walk, or until the elongated relaxed tendons have contracted. In infants tenotomy is as a rule unnecessary except, possibly, the division of the tendo calcaneus. Division of the plantar fascia is often necessary, of the tibialis posterior occasionally, of tibialis anterior rarely. The calcaneal and navicular ligaments may require division. Osteotomy

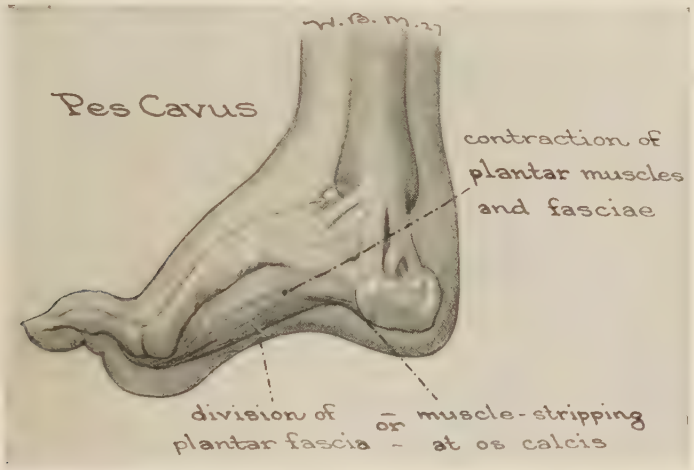


Fig. 1045.—Pes cavus. Indicating correction by division of the plantar fascia or by, better, muscle-stripping from the calcaneus.

of the neck of the talus, talusectomy (astragalectomy), and the multiple osteotomy of Hoke are reserved for the very marked and obstinate type. In the adult the deformity is treated by wrenching, operations upon the tendons, and talusectomy, as required in the individual case.

Paralytic talipes begins in the second or third year, usually from infantile paralysis, and is seldom bilateral. The joint is loose, the muscles are much wasted and paralyzed, and the growth of bone retarded. The foot is flabby, and can easily be restored to the correct position before late contractures have developed.

Treatment.—(1) Early massage, electricity, passive movements, and support by brace, splint, or bandage; (2) later, tenotomy, tendon grafting, brace, or arthrodesis.

Spastic talipes occurs with spinal sclerosis and cerebral palsy. *Pes cavus* or claw-foot, the longitudinal arch of the foot is exaggerated, often in association with hammer-toe.

Treatment.—In equinus cases, tenotomy or tenoplasty of the tendo calcaneus,

and fasciotomy of plantar fascia. For low heel, a transplantation of the tendon of the extensor proprius hallucis, which is so passed through a hole in the neck of the first metatarsal bone as to raise the dropped metatarsal. In severe cases talusectomy with the removal of the heads of the metatarsal bones may be necessary.

Painful heel (*policeman's heel*) may be due to trauma, rupture of fibers of tendo calcaneus, achillobursitis, exostoses, infection, hypertrophic arthritis.

Treatment.—Relief from strain, flat-foot, or gonorrheal infection; with local rest, orthopedic shoes, excision of exostoses. Achillobursitis is relieved by injecting 1 c.c. of a 3 per cent. solution of phenol into the sac by a fine hypodermic needle.

Metatarsalgia (*Anterior metatarsalgia; Morton's toe*—Morton, 1876) is a sudden, unendurable, burning cramp in anterior metatarsus (chiefly the fourth metatarsal head) while walking or standing, often necessitating the immediate removal of shoe. As a rule it is unilateral and due to flatness of the

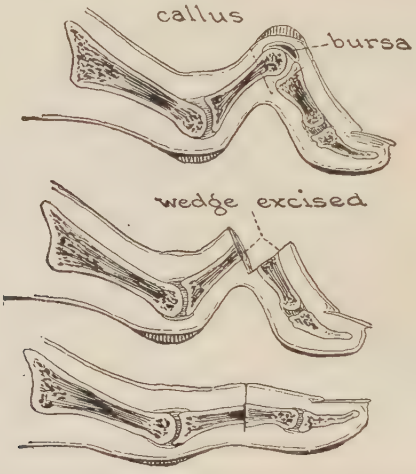


Fig. 1046.—Hammer-toe. Treatment by wedge-shaped excision of affected joint and overlying soft tissues.

transverse arch of foot. The condition is caused by pressure on the plantar nerves or bursæ by the heads of the metatarsal bones.

Treatment.—A bar of leather behind the tread may relieve the pain; a metal plate, accurately fitted and adjusted, is sometimes necessary. Strapping around the forefoot to restore the transverse arch, and especially the insertion of a fitted pad of leather under the insole behind the painful area often gives relief. The patient should wear broad orthopedic shoes. In severe, prolonged, resistant cases, removal of the intermetatarsal bursæ (Hirtschler), of the fourth metatarsal head, or amputation of the toe may be necessary.

Hammer-toe (*digitus malleus*) is characterized by flexion of the proximal interphalangeal joint, and dorsiflexion of the metatarsophalangeal joint. The prominent knuckle chafes on the upper part of the shoe, and the tip of the toe is pressed on the sole. Painful corns develop. Walking is difficult. The condition is often associated with hallux valgus.

Treatment is operative. Resection of the joint or amputation gives relief. Tenotomy is insufficient.

Hallux Rigidus or Flexus.—Stiffness of the great toe with osteo-arthritis, usually is associated with flat-foot. The flat-foot should be corrected and, if necessary, the head of the metatarsal excised.

Hallux Valgus.—The great toe is abducted and may, in extreme cases, lie over or under the second toe. The metatarsophalangeal joint is very prominent, usually overlaid by a bunion, and a septic bursitis may develop.

Treatment.—Orthopedic shoes with broad toes and a straight insole, with or without a corrective toe-post. Operation is desirable for the severe types, the enlarged metatarsal head being excised together with the bunion. In the Mayo operation the bunion is used to line the new joint. Passive and active movement should be started two or three weeks after the operation.

Hallux varus (*pigeon-toe*) is rare, and occurs in children with medial deviation of the toe. It may be corrected by bandage, splint, tenotomy of the abductor hallucis or, in extreme cases, by arthroplasty.

Displacement of the little toe may be congenital or acquired, and prove a source of great discomfort. The *treatment* is manipulative and mechanical in young people; operative in adults.

Ainhum is characterized by the formation of a circular constricting groove near the base of the toe with fibrosis and hyperkeratosis. It is usually unilateral and painless, occurs chiefly in men, and interferes with the nutrition of the toe by strangulation.

Treatment.—Linear division of constriction at one or more points or, if this fails, amputation of the toe.

INDEX

NOTE.—Page references to illustrations appear in *italic type*. Where there are several references to discussions of the same subject the more important references are printed in **bold-face type.**

A. B. C. powder, 139
Abbe, 620, 1090
Abbe's method of esophageal bougination, 869
Abdomen, friction fremitus in, 956
  tactile sensation in, 954
Abdominal actinomycosis, 172, **993**, 1078
  anus, formation of, in rectal carcinoma, 1220
  aorta, aneurysm, treatment, 409
    ligation, 634
    Macewen's method of compression, 80
    wounds of, 950
  colic in intestinal obstruction, 1059
  disease, diagnosis, 954
    by artificial pneumoperitoneum, 956
    by auscultation, 956
    by exploratory operation, 956
    by gastrodiaphany, 956
    by inspection, 954
    by palpation, 955
    by percussion, 956
    by roentgenography and roentgenoscopy, 956
  empyema in pneumococcus peritonitis, 985
  exploratory operation, 956
  fistulectomy, *1073*
  flap, transfer, to hand, 613
  incisions, 972
    relation to abdominal nerves, 954
  nerves, relation of incisions to, 954
  operations with peritonitis or intestinal obstruction, preoperative treatment, 588
  points, 954
  retractors, *601*
    Balfour's self-retaining, *1066*
  sections, clean, postoperative treatment, 588
    septic, postoperative treatment, 589
  wall, 953
    abscess, following fall, *960*
    anterior, relaxation of, 963, *964*
      weakness of, 963
    blood-supply, 953
    carcinoma of, secondary, 971
    color, in disease, 954
    congenital defects, 957
    contour, in disease, 954
    defects, 957
    Desjardin's point, 954
    desmoid tumors, 971
    diagnostic significance of conditions of, 954
    diastasis, 960
    echinococcus cysts, *955*
    emphysematous crackling in, significance, 955
    enlarged veins in, *955*
      significance, 955
    fibroid tumors, 971
    fibroma, 971
    hernia, 960
    imbrication, 967
    in disease, 954
    incisions, 972
    interdigitation, 969
    involuntary rigidity, 954
      significance, 955
    line of cleavage, 953
    lipectomy, *965*, *966*, 971
Abdominal wall, lipoma of, preperitoneal, 971
    McBurney's point, 954
    methods for strengthening, 967
    Morris' points, 954
    nerves, 953
    nodules in, 955
    obese and relaxed, *964*
    overdistention, 964
    parietal mass under, 955
    principal muscles, 953
    reinforcement with alien substances, 969
      with silver chain, *966*, 969
    relaxation, *964*
      etiology, 964
      lipectomy for, *965*, *966*, 971
      symptoms, 964
      treatment, 966
      with umbilical hernia, operation for, *968*, *969*, *970*, *971*, *972*
    Robson's point, 954
    subcutaneous injury, 960
    surface, in disease, 954
    tumors, 971
    weakness of, 963
      congenital, 964
      treatment, 966
    wounds, 960
      closed, with visceral injury, 961
        without visceral injury, 960
      gunshot, 963
      open, non-penetrating, 962
        penetrating, 962
      subcutaneous, 960
Abducens nerve, lesions, 730
  palsy after spinal anesthesia, 574
Abduction paralysis of thumb, treatment, 387
  treatment in fracture of neck of femur, 307
Abductor paralysis, bilateral, 840
Abrachius, 1288
Abrasion, 38
Abscess, 21, **27**, 141
  acute, 27
  alveolar, 807
  apical, 807
  appendiceal, 1101
  atheromatous, 391
  axillary, 881
  Brodie's, 231, **236**
  cerebellar, 710
  cerebral, 709
  chronic, 27
  circumscribed, of bone, 236
  cold, 27, 159, 772
    in tuberculous arthritis, treatment, 338
    of chest wall, 882
    treatment, 773
  embolic, 27
  extradural, 687
  gastric, 1004
  Hilton's method of treating, 27
  hot, 27
  iliac, 770
  intramammary, *889*, **892**
  ischiorectal, 1208
  lumbar, 769, 772
  metastatic, 27
  of abdominal wall following fall, *960*
  of angle of jaw, 853
  of anus, 1207
    cutaneous, 1207
    subcutaneous, 1208
Abscess of appendix, cecal fistula following operation, *1072*
    peritonitis secondary to, *980*
  of brain, 709
    frontal lobe, 710
    Gradenigo's syndrome, 709
    localization, 710
    occipital lobe, 710
    parietal lobe, 710
    temporal lobe, 710
  of breast, *889*, **891**
  of hypothenar space, 1299
  of kidney, 1234, **1235**
  of larynx, 839
  of liver, 1122
    amebic, 1122
    drainage, 1123
    multiple, 1123
    operation for, 1123
    pyemic, 1123
    pyogenic, 1122
    solitary, 1122
    subphrenic abscess and, differentiation, 988
    tropical, 1122
  of lower cervical vertebræ, 772
    thoracic vertebræ, 772
  of lumbar vertebræ, 769, 772
  of lumbosacral vertebræ, 772
  of lung, 928
    artificial pneumothorax in, 929
    complications, 929
    operative drainage, 929
    postural drainage, 929
    pulmonary tuberculosis and, differentiation, 929
    treatment, 929
  of midpalmar space, 1299
  of muscle, 382
  of palmar surface of finger, 1297
  of pancreas, 1152
  of rectum, 1207
    cutaneous, 1207
    subcutaneous, 1208
  of spine, 769
    cold, 772
  of spleen, 1159
  of stomach, 1004
  of thenar space, 1299
  of upper cervical vertebræ, **772**
  palatine, 807
  palmar, 1298
  pelvirectal, 1209
  peri-appendiceal, localized, 1101
  perinephric, 1235
  periodontal, 807
  peritonsillar, 831
  periurethral, complicating urethral stricture, 1271
  pointing, 27
  postpharyngeal, 770, 830
  premammary, *889*, **892**
  prostatic, gonorrheal, treatment of, 1264
  psoas, 769, **770**, 915
    femoral hernia and, differentiation, 1197
    inguinal hernia and, differentiation, 1183
  pyemic, 27
  retromammary, *889*, **892**
  retropharyngeal, 830
  retrorectal, 1208
  sacrococcygeal, 758
  secondary to perforated gastric ulcer, 1012

Abscess, subpectoral, 881
subphrenic, 986, 988
empyema and, differentiation, 915
extraperitoneal, 987
liver abscess and, differentiation, 988
intraperitoneal, 986
pleural effusion and, differentiation, 988
treatment, 989
subscapular, 882
suprascapular, 882
termination, 27
treatment, 27, 142
tuberculous, of bone, chronic, deep, 238
Tumba-fly, 59
varieties, 27
Acanthoma, 210
Acapnia, 113
in anesthesia, 534
Accessory auricles, 845
nerve, injury, 852
complicating operations on thyroid, 488
lesions, 736
pocket in gastric ulcer, 1007
portal system of Sappey, 1126
suprarenal bodies, 498
Accoucheur's hand in gastric tetany, 1031
Acervuloma, 201
Acetabulum, fracture, 303
floor, 303
posterior and upper lip, 303
Acetylarsan in syphilis, 165
Acetylene anesthesia, 552
Achilles' tendon, contracted, 1304
Achillobursitis, 388
Achillodynia, 384, 388
Acholuric familial jaundice, 1160
Achondroplasia, 227
Achondroplastic dwarfs, 227
Achylia gastrica nervosa, 1033
Acid, bichlorid solution, 135
boric, 137
and iodoform dusting-powder, 138
carbolic, as disinfectant, 133
picric, 137
tannic, for burns, 69
Acid-base equilibrium, 534
Acidosis, diabetic, 124
in anesthesia, 534
in chloroform anesthesia, 547
in hepatic disease, 1120
treatment, 1121
non-diabetic, 124
Acinous adenoma of breast, 897
Ackley, 55
Acne, Roentgen-rays in, 517
treatment, 142
Acoustic nerve, lesions, 734
Acrocyanosis, 106
Acromegaly, 190, 227, *491*, **494**
hand in, *495*
Acromial bursa, 390
inflammation, 390
Acromion, fracture, 281
Acroparesthesia, 106
Actinic burns, 66
Actinomyces, 170
maduræ, 175
Actinomycosis, 170
abdominal, 172, **993**, 1078
head-and-neck, 171
of bones, 239
of chest wall, 833
of face, 797
and jaws, 812
of intestines, 1078
chronic, 1078
pyemic, 1078
of liver, 1126
of mandible, *811*
of neck, *854*, 855
of parotid, 829
of peritoneum, 993
of tongue, 822
pulmonary, 172
treatment, 172
Actol, 136
Actual cautery, 516
Acupressure, 86
in hemorrhage from navel, 958
Acupuncture as counterirritant, 517
in sciatica, 436
Acute miliary carcinosis, 208
Adactylism, 1289
Adamantinous multilocular cyst, 205
Adami, 1135
Adams, 269
Addison's disease, 498
Adductor canal, ligation of femoral artery in, 637
Aden ulcer, 179
Adenitis of face, 795
Adenocarcinoma of appendix, 1118
of bronchus, 936
of rectum, 1218
of thyroid gland, 484
Adenocele, 203, 205
Adenofibroma, 187
Adenoid carcinoma of lip, 802
epithelioma, 214
Adenoids, 832
Adenoma, 203
colloid, of thyroid gland, 483
cystic, 203
of breast, 897
fetal, 476
of thyroid gland, 483
malignant, of thyroid gland, 484
of adrenals, 499
of breast, 897
of face, 802
of pancreas, 1155
of pituitary, 495
of rectum, 1218
of scalp, 668
of small intestine, 1079
endometrial, 1079
of stomach, 1033
of testes, 1285
of thyroid gland, 483
racemose, 203
toxic, 479
of thyroid gland, 483
heart disease and, 484
tubular, 203
of breast, 897
Adenomatous goiter, 476
polyp, 203
of upper lip, *203*
Adhesions, intestinal, obstruction from, 1068
intra-abdominal, 989
special varieties, 990
mesocolic, 990
splenic pericolic, 990
within joint, 342
Adhesive inflammation, 21
pericardiomediastinitis, 945
pericarditis, 945
cardiolysis in, 945
peritonitis, chronic, 989
tuberculous peritonitis, 991, 992
Adolescent flat-foot, 1306
rickets, 224
Adrenal glands, 498. See also *Suprarenal glands.*
tumor, 1241
Adrenalin, 498
Adson, 497, 498, 848
Aërocele, 833
Aërophagia, 1023
Aëroplane type of support of arm, *285*
African lethargy, 62
Agenetic fracture, 257
Agglutinative inflammation, 21
Agglutinin test, Lee's, in blood-transfusion, 91
Aglossia, 819
Agnathia, 785
Agnew's operation for syndactylism, *1291*, *1292*
Agonic intussusception, 1062
Ainhum, **463**, 1311
Air embolism, cerebral, 933
complicating operations on thyroid, 488.
encephalography, 694
exposure of wounds to, 47
Airol, 138
Air-passages, foreign bodies in, 833
operations, 842
Aitken's treatment of contracted tendo achillis, 1304
Akoria, 1033
Albee, 271, 769
Albee's bone-motor, *271*
operation for Pott's disease, 771
for ununited fracture of neck of femur, 308
sliding bone-graft, *272*
treatment of backward dislocation of hip, 369
Albers-Schönberg disease, 225, **226**
Albert's disease, 388
intestinal suture, 1087
Alcohol as disinfectant, 130, 132
boric, 137
injection in trigeminal neuralgia, 728
of nerves supplying spastic muscles, 783
Alcoholic cirrhosis, 1126
coma, 118
delirium, 120
serous meningitis, 121
solution, dilute, as wet dressing for wounds, 51
Alcoholism, cerebral compression and, differentiation, 703
Aleppo boil, 178
Alexins, 26
Alimentary canal, anastomotic operations on, 1090
Alkali reserve, 534
Alkalinosis in hepatic disease, 1120
treatment, 1121
in intestinal obstruction, 1059
intestinal, 1060
Alkalosis, intestinal, 1060
Allen, 763, 783
Allis, 597
Allison and Schwab, 783
Alloplastic operation for closure of defects of skull, 686
Alopecia, 463
Altitudinal index, 669
Alum enema, 504
Alveolar abscess, 807
sarcoma, 199
Alveolus epulis, 812
Alvinoliths in intestines, 1061
Alypin, local anesthesia by, 559
Amastia, 888
Amazia, 888
Ambrine for burns, 69
Amebiasis of gall-bladder, 1136
Amebic abscess of liver, 1122
Amelus, 1288
American leishmaniasis, 179
Ammonium ichthyol-sulphonate, 139
Amnesia complicating skull injuries, 708
Amœba coli, 65
Amputating knives, 595
Amputation, 641
Babcock's interilio-abdominal, 660–663
Bunge's, 641
by enucleation, 647
Carden's, of leg, 658
Chopart's, of foot, 655
Forbe's modification, 655
cinematic, 642
cineplastic, 642
circular, 645
modified, 646
classification, 641
club motor, 642
Condon's, of foot, 655
covering bone, 648
Dupuytren's, of shoulder, 653
flap, 646
of leg, *647*
Gritti-Stokes, of leg, 658
guillotine, 647
through thigh, *648*
Hey's, of foot, 655
historical, 641
in crushing injury, 42
instruments required, 645
interilio-abdominal, Babcock's, 660–663
Keen's, *659*
interscapulothoracic, 653
Jordan's, of hip, *659*
of shoulder, 653
Keen's interilio-abdominal, *659*
Kocher's, of hip, *659*
Larrey's, of hip, 659

Amputation, Lisfranc's, of foot, 655
loop motor, 642
metatarsophalangeal, of foot, 653
neuroma, 190, 431, 644
of ankle, 656
Pirogoff's, 656
Ferguson's modification, 656
Le Fort's modification, 656
Syme's, 656
with removal of malleoli and articular surface of tibia, 656
of breast for cancer, *906*, *907*, *908*, *909*, *910*, *911*
of elbow, 651
of finger, 650
through distal phalanx, 650
through middle phalanx, 650
through proximal phalanx, 650
of foot, 653
Chopart's, 655
Forbe's modification, 655
Condon's, 655
Hey's, 655
Lisfranc's, 655
metatarsophalangeal, 653
midtarsal, 655
Skey's, 655
subtalar, 656
tarsometatarsal, 655
through metatarsus, 655
of hand, 650
of hip-joint, 659
Jordan's, *659*
Kocher's, *659*
Larrey's, 659
of leg, 657
Carden's, 658
Gritti-Stokes, 658
oval, *657*
racket incision, 646
Smith's, 657
supracondyloid, 658
Teale's, 657
through thigh, 658
of prolapsed rectum, 1216
of shoulder, 651
anterior racket, 652
Dupuytren's, 653
external racket, 653
interscapulothoracic, 653
Jordan's, 653
Larry's, 653
long external, short internal flap, 653
Spence's, 652
of thumb, 650
of wrist, 651
osteoplastic, 642
plastic motor, 642
position of scar, 647
primary, 642
pylons, 649
site, 648
Skey's, of foot, 655
Smith's elliptical, of leg, *646*
modified circular, of leg, *646*
of leg, 657
racquet, of leg, *646*
special, 650
Spence's, of shoulder, 652
stumps, 643
affections, 643
after interilio-abdominal amputation, *663*
appearance, 643
cicatrix, 643
desirable features, *649*
lengthening, 644
progression, 643
reamputation, 644
skin-grafting, 644
stability, 643
support, 643
subtalar, of foot, 656
Teale's, 641
of leg, 657
technic, 645
temporary artificial leg, 649
through foot, 655
traumatic, of fingers, *43*
Vanghetti's, 642
with tourniquet, 645
Anacidity, gastric, preoperative treatment, 586
Anakhré, 176
Analgesia, 533
Anaphylaxis in intravenous therapy, 514
test for susceptibility, 514
Anastomosis, accessory-facial (spino-facial), Cushing's, 733
aneurysm by, 194, 396
Billroth's, modifications of, *1043*
entero-entero, historical, 1045
Fränkel-Babcock, *1043*, *1048*
gastric and intestinal, mechanical aids in, 1090
hypoglossal, 733
intestinal, 1090
aseptic, by basting stitch method, 1090
by guillotine method, 1092
methods, 1092
suture, 1090
of facial nerve, 732
of ureters for exstrophy of bladder, 1249
peritoneosaphenous, for ascites, 994, *995*
saphenous peritoneal, for cirrhosis of liver, 1127
ureteral, 1244
Anastomotic operations on alimentary canal, 1090
Anatomic tubercle, 467
Anatomical wart, 159
Anchylostoma duodenalis, 62
Anderson's method of lengthening tendo achillis, *385*
Andrews, 548, 1022
Andrews' operation for inguinal hernia, 1193
Anel, 403
Anel's operation for aneurysm, *403*
Anemia, brick-maker's, 62
miner's, 62
pernicious, 1161
blood-transfusion in, 1161
radium treatment, 1161
splenectomy for, 1161
splenic, 1160
chronic, of children, 1160
hematemesis in, 1024
tunnel, 62
von Jaksch's, 1160
Anesthesia, acapnia in, 534
acetylene, 552
acidosis in, 534
anesthol, 552
anoxemia in, 534, 535
apnea in, 534
Arnott's, 554
arterial, 579
atelectasis in, 535
block, 554
blood in, 539
blood-pressure in, 536
brachial palsy in, 540
brachial-plexus, 577
brain in, 538
bronchopneumonia in, 535
carbon dioxid, 552
caudal, 575
chloroform, 546
acidosis in, 547
administration, 546
dangers, 547
circulatory system in, 536
combined, 545
conduction, 534, 554
dangers, 536
diabetes in, 539
digestive tract in, 538
ductless glands in, 538
epidural, 575
ether, 540
closed method, 544
combined, 545
complications after, 543
contraindications, 540
danger signs, 543
intratracheal insufflation, 545
Klapp's method, 545
open drop method, 542
percentage required, 541
physiologic action, 541
rebreathing method, 544
rectal, 545
Anesthesia, ether, rectal, in childbirth, 546
semiclosed method, 544
sequence, 545
stages, 541
technic, 542
vapor method, 544
ethyl chlorid, 552
ethylene, 551
versus nitrous oxid anesthesia, 552
extradural, 575
gas-pain in, 536
gastro-intestinal complications, 535
general, 533
glove, 433
history, 553
hypercapnia in, 534
in bronchitis, 537
in operation for peritonitis, 982
on heart, 947
in pneumonia, 537
in pulmonary tuberculosis, 537
in shock, 538
in treatment of dislocations, 349
indications, 534
infiltration, 534, 554
with cocain, 557
inhalation pneumonia in, 538
instillation, 554
intradural, 561
intratracheal insufflation, 545
intravenous, 553
ketosis in, 534
kidneys in, 538
liver in, 538
local, 534, 554
by alypin, 559
by anesthesin, 560
by apothesine, 559
by benzocain, 560
by benzoxy-dimethylamino-methyl - dimethylamino - butane hydrochlorid, 559
by benzoyl-dimethylamino-methyl-propanol hydrochlorid, 559
by butesin picrate, 561
by butyn, 557
by chlorbutanol, 561
by chloretone, 561
by cocain, 556
by cold, 554
by ethenyl-paradiethoxy-diphenyl-amidin hydrochlorid, 560
by ethyl aminobenzoate, 560
by gamma-diethylamino-propyl-cinnamate hydrochlorid, 559
by holocain hydrochlorid, 560
by novocain, 558
by orthoform, 561
by para-amino-benzoyl-gamma-dinormal-butyl-amino-propanol sulphate, 557
by phenacain, 560
by procain, 558
by stovain, 559
by trichlor-tertiary-butyl-alcohol, 561
chemical, 556
lumbar, 561
machine, Heidbrink's, *550*
McKesson's, *544*
medullary, 561
musculospiral palsy in, 540
nitrous oxid, 548
olefiant gas, 551
parasacral, 576
paravertebral, *575*, 577
peripheral, 554
physiology, 534
plexus, 554
precautions in, 539
preliminary examination, 536
preparation of patient, 539
presacral, 575
pulmonary complications, 535
pulse rate in, 536
radicular, 561
regional, 534, 554
vascular, 554
respiratory tract in, 537
sacral, 575
anterior, 575
posterior, 576
sequence, 545

Anesthesia, somnoform, 552
spinal, 533, **561**. See also *Spinal anesthesia.*
splanchnic, anterior, 578
posterior, 578
Stange's test, 536
stocking, 433
surface, 554
surgical, 533
transsacral, 576
urinary system in, 538
venous, regional, 578
Anesthesin, local anesthesia by, 560
Anesthetic powders for wounds, 47
Anesthetics. See *Anesthesia.*
and shock, 115
Anesthetist, 582
preparation, 539
Anesthol anesthesia, 552
Aneurysm, **394**
Anel's operation, *403*
Antyllus' operation, *403*, 407
arterial, false, treatment, 410
arteriovenous, 396
treatment, **47**, 410
axial, 396
Brasdor's operation, *403*
bruit, 399, **400**
by anastomosis, **194**, 396
cirsoid, **194**, 396, 799
of scalp, 669
treatment, 196
congenital, 394
differential diagnosis, 401
diffused, 394
dissecting, 391, **395**
ectatic, 396
embolic, 395
end-to-end arterial suture, **407**, *408*
excision in, 407
false, 391, **394**
fusiform, 398
hernial, 394
Hunter's operation, *403*
idiopathic, 394
ligation in, 407
Matas' operation, *405*, *406*, **407**
miliary, 395
Moore-Corradi operation, 404
mycotic, 398
needles, 603
obliterative operation, 407
of abdominal aorta, treatment, 409
of aorta, Babcock's anastomotic operation, *951*
rupture of, *950*
of bone, 244, **253**
of brachial artery, *407*
of external iliac artery, *394*
of renal artery, 1240
of thoracic aorta, Babcock's operation, 409, *410*
Oliver's sign, 400
operations for, curative, 407
special, 409
pain in, 400
pathology, 398
plexiform, 396
popliteal, Matas' operation, *405*, *406*
prognosis, 401
Rasmussen's, 398
reconstructive operation, 408
sacculated, 397, **398**
Shekelton's, 395
Sibson's sign, 400
spongy, 469
tracheal tugging in, 400
traction, 398
traumatic, **394**, 410
circumscribed, 394
diffused, 394
of scalp, 669
treatment, 46
treatment, 401
by substances within sac, 404
curative operation, 407
local, 402
medical, 401
obsolete, dangerous, and ineffectual methods, 402
true, 394
Tuffnell's treatment, 401
Valsalva's treatment, 401
varicose, 396
Aneurysm, varieties, 394
verminous, 395
Wardrop's operation, *403*
worm, 395
Aneurysmal bruit, 399, **400**
varix, 396
treatment, 411
Aneurysmorrhaphy, Matas', *405*, *406*, 407
obliterative, 407
reconstructive, 408
Angel-wing deformity, 1289
Angina, Ludwig's, 144, **853**
pectoris, 946
acute, 946
aortic, 946
chronic, 946
operations for, **946**
sine dolore, 946
Vincent's, 818
Angioma, 193
arterial, 194
arteriale plexiforme, 194
racemosum, **194**, 799
cavernous, 193, **194**
of chest, 885
of neck, 857
fissural, 194
glomeruliforme, 194
of bladder, 1257
of face, 799
of forehead, treatment, *196*
of liver, 1128
congenital, 1128
of parotid, 829
of stomach, *1034*
plexiform, 195
simple hypertrophic, 194
simplex, 194
of neck, 857
venosum, 194
subcutaneous plexiform, 799
telangiectatic, 193, **194**
venosum racemosum, 799
Virchow's fissural theory, **194**
Angiosarcoma, 201
Angiotribe, 84
Angle, Bollin, and Blair, 805
Angle, facial, of Camper, 670
Angler's elbow, 381
Angular artery, digital compression, 80
splints, 531
internal, *298*
Anilin cancer of bladder, 206
Animal parasites in bladder, 1256
Animals, lower, diseases produced by, 36
injuries and diseases received from, 55
Ankle, amputation, 656
Pirogoff's, 656
Ferguson's modification, 656
Le Fort's modification, 656
Syme's, 656
with removal of malleoli and articular surface of tibia, 656
fracture dislocation, 323
optimum position for ankylosis, 265
sprained, 331
strapping, *330*
tailor's, 390
Ankle-joint, arthrotomy, **344**
dislocation, 377
Ankylosis, 342
bony, 342
false, 342
fibrous, 342
of jaws, 806
optimum position for, in dislocations, 351
in fractures, 264
true, 342
Annamite sore, 179
Annelida, bite of, 61
Annular rickets, 225
Anoci-association, 113, **533**
in exophthalmic goiter, 482
Anociation, 533
Anorchidism, 1281
Anorectal fistula, 1209
Anorexia nervosa, 1033
Anosmia, 725
Anotia, 785
Anoxemia in anesthesia, **534**, 535
venous, 113
Anstie's limit of moderation in drinking, 120
Anthrax, 152
carbuncle and, differentiation, 465
cutaneous type, 152
edema, 153
intestinal, 153
of face, 793
pulmonary, 153
septicemia, 152
Antisepsis, 128
Antiseptic poultice for wounds, 49
powders for wounds, 48
solutions for wounds, 50
Antiseptics, **128**, 129
in peritoneum, 984
Antitetanic serum in burns, 70
Antitoxin for snake bites, 58
Antivenene, 58
Antyllus, 403, 641
operation for aneurysm, *403*, 407
Anuria, 1224, **1246**
calculous, 1232
non-obstructive, 1224
Anus, 1206
abdominal, formation of, in rectal carcinoma, 1220
abscess, 1207
cutaneous, 1207
subcutaneous, 1208
artificial, following gunshot injury, *1071*
carcinoma, 1218
cocain anesthesia, 557
congenital malformations, 1206
epithelioma, squamous, 1218
fissure, 1211
submucous, 1212
fistula, 1209
imperforate, 1206
lumbar, formation of, in rectal carcinoma, 1220
sacral, formation of, in rectal carcinoma, 1220
sarcoma, 1221
stricture, 1216
syphilis, 1217
ulcer, irritable, 1211
umbilical, 958
Aorta, 943
abdominal, aneurysm of, treatment, 409
ligation of, 634
Macewen's method of compression, 80
wounds of, 950
aneurysm, Babcock's anastomotic operation, *951*
rupture of, *950*
spontaneous rupture, 950, *950*
suture of, 950
thoracic, aneurysm of, Babcock's operation, 409, *410*
treatment, 409
wounds of, 950
wounds, 950
Aortalgia, 946
Apelt-Nonne test of cerebrospinal fluid, 746
Aphasia, motor, complicating skull injuries, 708
Aphonia, 839
Aphthæ, Bednar's, 822
Aphthous ulcers, 818
Apical abscess, 807
Apicoectomy, 807
Apiotomy in bronchiectasis, 932
Apnea in anesthesia, 534
Apophyseal fractures, 255
Apoplexy, cerebral compression and, differentiation, 703
traumatic, 706
Apothesine, local anesthesia by, 559
Apparatus methods of blood-transfusion, 93
Appendectomy, *1108*, *1109*, *1110*, *1111*, 1112, *1113*
Battle's incision for, 1114
Davis' incision for, 1114
gridiron incision for, *1110*, 1112
incision, *1108*
McBurney's incision for, *1110*, 1112

Appendectomy, needle-holder for, *1108*
purse-string suture for, *1111*
retractors for, *1108*, *1114*
thumb forceps for, *1108*
viscera forceps for, *1108*
Appendiceal abscess, 1101
incisions, 972
Appendicitis, 1095
acute, 1095
from stricture, *1099*
hemorrhage in, 1105
ileus in, 1100
latent period, 1101
leukocytosis in, 1100
lymphadenopathy in, 1100
obstipation in, 1100
perforated duodenal ulcer and, differentiation, 1011
perforative, 1101
pneumococcic peritonitis and, differentiation, 986
position of patient in, 1100
purulent, *1098*
special forms, 1101
tachycardia in, 1100
tenderness in, 1098
terminations, 1104
tormina in, 1098
vesical symptoms, 1100
atrophic, *1096*
bacterial infection, 1097
biliary colic and, differentiation, 1103
cholecystitis and, differentiation, 1103, 1141
chronic, 1095
biliary disease in, 1106
catarrhal, *1106*, *1107*
chronic enterocolitis in, 1106
dyspepsia in, 1105
interstitial, *1107*
peptic ulcer in, 1106
complications, 1102
Dietl's crisis and, differentiation, 1103
fecal fistula following operation, 1117
gangrenous, *1099*, 1101
hemorrhage following operation, 1114
ileus following operation, 1116
increased temperature in, 1099
jejunal toxemia following operation, 1116
nausea in, 1098
obliterative, *1096*
Ochsner's treatment, 1110
operation in, 1107
indications for delay, 1107
peptic ulcer and, differentiation, 1017
perforated peptic ulcer and, differentiation, 1103
peritonitis in, 1102
following operation, 1115
feeding in, 1116
phlegmonous, 1101
pleurisy and, differentiation, 1104
pneumonia and, differentiation, 1104
postoperative complications, 1114
pylephlebitis in, 1102
following operation, 1115
renal colic and, differentiation, 1103
salpingitis and, differentiation, 1103
senile, *1096*
strangulated hernia and, differentiation, 1104
subacute, 1095
thrombosis after, 95
treatment, medical, 1106
operative, 1107
typhoid fever and, differentiation, 1104
ureteral colic and, differentiation, 1103
Appendicostomy, 1090
Appendicular dyspepsia, 1105
Appendix, abscess, cecal fistula following, *1072*
peritonitis secondary to, *980*
adenocarcinoma, 1118
artery of, *1097*
blood-supply, *1096*
carcinoma, 1118
epiploica, affections of, 1085
hematoma of, *1084*
gangrene, *1097*
from stricture, *1099*
Appendix, inflammation of, 1095
intestinal parasites in, 1095
mucocele, 1117, *1118*
omentula, affections of, 1085
oxyuris in, 1097
vermiform, 1095
anomalies of, 1095
inflammation of, 1095
Appetite, loss of, 1033
Apple-jelly nodules, 796
Apus, 1289
Arachidic bronchitis, 833, **924**
Arachnidia, bites of, 60
Arachnoid fibroblastoma, 775
Aran-Duchenne syndrome, **447**
Archibald and Wren, 90
Archocele, 1215
Area medullovasculosa, 747, 748
Argas moubata, bite of, 60
persicus, bite of, 60
Argentoprotein mite, 136
Argentoproteinum fortius, 137
Argyn, 136
Argyrol, 136
Aristol, 138
Arm, glass, 381
lawn-tennis, 381
lymphedema, 420
sling for, *529*
Arnott's anesthesia, 554
Arsenical necrosis of jaw, 809
periostitis of jaw, 809
Arterial anesthesia, 579
angioma, 194
false aneurysm, treatment, 410
forceps, 600
hematoma, treatment, **46**, 88
hemorrhage, 77
acupressure for, 86
primary, treatment, 87
recurrent, treatment, 87
secondary, treatment, **46**, 87
treatment, **46**, 87
suture, 950
end-to-end, for aneurysm, **407**, *408*
technic, *411*
thrombosis of extremities, 97
treatment, 46
varix, 396
Arteries, atheroma, 391
diseases, 391
inflammation, 391
ligation, 84, 622
at point of election, 624
of necessity, 624
blood-pressure and, 624
rules for, 86
of stomach, points of ligation in gastrectomy, *1040*
sections of, transplantation, 619
vertebral, digital compression, 80
Arteriorrhaphy, end-to-end, for aneurysm, **407**, *408*
Arteriosclerosis, 391
in diabetes, 122
secondary softening, 391
Arteriosclerotic gangrene, 102
Arteriotomy, 515
Arteriovenous aneurysm, 396
treatment, **47**, 410
Arteritis, embolic, 391
septic, 391
simple plastic, 391
syphilitic, 392
traumatic, 391
Artery, abdominal aorta, ligation, 634
angular, digital compression, 80
appendicular, *1097*
axillary, digital compression, 80
ligation of, 632
brachial, digital compression, 80
ligation of, 633
carotid, common, right, ligation of, 626
digital compression, 80
external, ligation of, 627
internal, hemorrhage from, 706
ligation of, 629
common carotid, digital compression, 80
dorsalis pedis, ligation of, 639
facial, ligation of, 630
femoral, ligation of, 637
gluteal, inferior, ligation of, 636
Artery, gluteal, superior, ligation of, 636
gustatory, ligation of, 630
hypogastric, digital compression, 80
ligation of, 635
iliac, common, ligation of, 635
external, digital compression, 80
ligation of, 636
internal, ligation of, 635
innominate, ligation, 625
labial, digital compression, 80
lingual, ligation of, 630
maxillary, external, digital compression, 80
ligation of, 630
meningeal, middle, anterior branch, ligation, *628*
hemorrhage from, 706
midcolic, *1041*
occipital, ligation of, 631
peroneal, ligation of, 640
popliteal, digital compression, 81
ligation of, 638
pulmonary, ligation of branches of, 942
radial, ligation of, 633
renal, aneurysm of, 1240
sciatic, ligation of, 636
subclavian, digital compression, 80
ligation of, 631
temporal, digital compression, 80
ligation of, 630
thyroid, inferior, digital compression, 80
ligation of, 630
superior, Crile's method of incision, 629
ligation of, 629
tibial, anterior, ligation of, 638
posterior, ligation of, 639
ulnar, ligation of, 633, **634**
vertebral, ligation of, 630
Arthralgia, syphilitic, 338
Arthrectomy, 344
and erasion in acute arthritis, 334
Arthritis, 329, **332**
acute, 332
arthrotomy in, 333
Willem's treatment, 333
arthrectomy and erasion in, 334
deformans, 340
degenerative, 340
gonorrheal, 148, **334**
hypertrophic, 340
osteo-, 340
pneumococcal, 334
pyemic, 335
rheumatic, 335
rheumatoid, 340
septic, of wrist, 1209
serous, 21
syphilitic, 338
tuberculous, 335
treatment, 337
typhoidal, 334
Arthrodesis, after-treatment, 345
of knee-joint, 345
Arthropathy, hypertrophic pulmonary, 229
tabetic, 340
Arthroplasty, 344
after-treatment, 345
Arthrotomy, 343
in acute arthritis, 333
of ankle-joint, 344
of elbow-joint, 343
of hip-joint, 343, **345**
of knee-joint, 343, **345**
of shoulder-joint, 343, **345**
of wrist-joint, 343
Articular fractures, 257
processes of spine dislocation, 759
Artificial anus following gunshot injury, *1071*
joint, formation, 344
larynx, 844
leg, temporary, 649
pneumoperitoneum, 956
pneumothorax, 940
in abscess of lung, 929
in bronchiectasis, 932
Loving's pressure apparatus, *940*
technic, 941
respiration, 500

Artificial respiration, Babcock's method, 501
Hall's method, 500
Howard's method, 500
Laborde's method, 501
Schäfer's method, 501
Silvester's method, 500
Asafetida enema, 504
Ascaris lumbricoides, 61
vermicularis, 62
Aschner's phenomenon, 479
Ascites, 993
chylous, 420, 994
epiplopexy for, 995
Handley's lymphangiorrhaphy for, 994
hemorrhagic, 994
in tuberculous peritonitis, 992
introduction of hardened blood-vessels for, 994
paracentesis abdominis for, 994
peritoneosaphenous anastomosis for, 994, *995*
serous, 994
Southey's capillary tubes for, 994
splenectomy for, 995
Talma operation, 994
Ascitic tuberculous peritonitis, 991
Asepsis, 128
Aseptic powders for wounds, 47
wounds, 36
Ashhurst, 324, 1104
Asphyxia, artificial respiration in, 500
in hyperplasia of thymus, *489*
Aspirating bottle, Jackson's, *925*
Aspiration, 515
of thorax, 918
Aspirator, Potain's, *515*
Asthenia, postoperative treatment, 589
Asthma, Pott's, 489
thymic, 489
Astley, 885
Astragalus, dislocation, 379
fracture, 327
Astringents, chemical, in arrest of hemorrhage, 88
Atelectasis, 833
in anesthesia, 535
Athelia, 888
Atheroma, 220
of arteries, 391
of chest, 884
syphilitic, 393
Atheromata of face, 801
Atheromatous abscess, 391
Atlas, fracture, 761
Atmocausis, 597
Atony of stomach, 1025
Atresia, congenital, of esophagus, 861
of intestines, 1054
of larynx and trachea, 833
of urethra, 1258
of meatus urinarius, 1277
of mouth, 784
Atria venosum, compression of, 951
Atrophia unguium, 473
Atrophic appendicitis, *1096*
fracture, 257
polyarthritis, 340
scirrhus, 208
cancer of breast, 903
Atrophy of muscles, 381
of nails, 473
senile, of skull, 683
Auditory nerve, lesions, 734
Auer, 502
Auer and Meltzer, 545, 878
Auricles, accessory, 845
cervical, 845
Auricular fibrillation complicating operations on thyroid, 489
nerve, great, paresthesia of, 851
Auriculotemporal nerve, lesions, 730
Aurinasal leishmaniasis, 179
Auscultation in fractures, 261
of esophagus, 860
Autoclaves, 131
Autocondensation, therapeutic uses, 518
Autohemotherapy, 513, 515
Autoplastic operation for closure of defects of skull, 686
Autoserotherapy, 513
Avulsion, 40
fractures, 257
Avulsion of scalp, 666
phrenic, 942
Axial aneurysm, 396
Axilla, follicular infection, 144
Axillary abscess, 881
artery, digital compression, 80
ligation, 632
infections, 881
nerve, injuries, 449
Axilla-shoulder-elbow bandage, 526
Ayer's test for spinal block, 745
Azotorrhea in pancreatic disease, 1150

Babcock's anastomotic operation in aortic aneurysm, *951*
costal periosteotome, *920*
digital transthoracic massage, 948, *948*
gravity localization method of spinal anesthesia, 566
hernioplasty, 1186, *1187*, *1188*, *1189*, *1190*, *1191*, *1192*, *1193*, *1194*
interdigitation of abdominal wall, 969
operation for umbilical hernia, 1199
interilio-abdominal amputation, 660–663
light solution for spinal anesthesia, 565
method of artificial respiration, 501
needle-holder, *606*
nerve clamp, *440*
operation for aneurysm of thoracic aorta, 409
for prognathous jaw, 805
for rerouting median nerve, *452*
for spina bifida, *753*, *754*, 755, *756*, *757*, *758*
for varicose veins, 416, *417*
retractor and periosteal elevator, 235
rib-props, 927
rib-spreader, *927*
self-filling syringe for local anesthesia, *556*
silver chain for incisural hernia, 1203
trocar, *919*
viscera forceps, *1067*
Bacelli, 404
Bacillus aërogenes capsulatus, 148
anthracis, 152
coli communis, 146
infection, 146
Koch's, 158
lepræ, 173, 174
mallei, 172
meyerillus, 148
of malignant edema, 148
pyocyaneus, 147
infection, 147
reglillus crogrediens, 148
rhinoscleromatis, 176
sporogenes, 148
tetani, 149
tuberculosis, 158
welchii, 148
Back, broken, 764
golfer's, 381
hunch-, 770
laborer's, 381
poker, 767
Bacteremia, 127
staphylococcus, 142
streptococcic, 143
Bacteria, pyogenic, 141
in peritoneum, 976
Bacterial gangrene, 109
Bactericides, 128
Bacteriophage, 141
powders for wounds, 49
Bacterium tularense, 156
Bag and belt for colostomy, *1090*
Bagdad boil, 178
Bainbridge, 621
Baker, 331
Baker's cysts, 331, 343
in osteo-arthritis, 341
Baking in inflammation, 23
Balanic hypospadias, 1278
Balanitis, 1279
gangrenous, 157
Balanoposthitis, 1279
Balanoposthomykosis, 157
Balantidium coli, 65
Baldness, 463
Balfour, 1006, 1009, 1018, 1045, 1046
Balfour's modification of Reichel-Polya gastrectomy, *1039*
self-retaining abdominal retractor, *1066*
Balkan frame, *314*
Ballance and Stewart, 733
Ball's operation for pruritus ani, 1216
salicylic solution, 137
Band, ideal, 998
Parham-Martin, 271
Bandage, 520
axilla-shoulder-elbow, 526
Barton's, 522, *523*
binocle, 524
capeline, 524
circular, 521
crossed, of eye, 524
demigauntlet, *522*
Desault's, 525, 526
dextrin, 531
elastic, 530
Esmarch's elastic rubber, *81*
figure-of-8, 522
descending, 522
fixed, 530
flour-paste, 531
for both eyes, *524*
four-tailed, of head, 527
Galen's, 528
gauntlet, *522*
Gibson's, 523
glue-and-oxid-of-zinc, 531
handkerchief, 529
immovable, 530
knotted, 522
many-tailed, 528
Martin's, 530
oblique, 521
poor man's, 528
recurrent, 521
of head, 524
roller, 520, 522
double, 520
single, 520
Scultetus, 528
silicate, 531
six-tailed, 528
soluble glass, 531
spica, 522
of groin, 525
of shoulder, 524
spiral, 521
reverse, 521
starch, 531
stiff, 530
supporting, postoperative, 592
T-, 526
tailed, 526
twisted, 522
Velpeau's, 525
water-glass, 531
Y-, 526
Bandaging, 520
Bands for fractures, 271
Banjo-splint, *299*
Banti's disease, 1160
tuberculous peritonitis and, differentiation, 992
Bárány's tests, 694
Barasty incision for exposure of heart, *949*
Barbadoes leg, 187, *421*, 461
Barington, 741
Barker's gravity localization method of spinal anesthesia, 567, *568*
Barlow, 224
Barney, 148
Barrel-chest, 873
Bartholinitis, gonorrheal, treatment, 1266
Bartholin's duct, 825
Bartlett, 969, 1203
Barton's bandage, 522, *523*
fracture, 296
Basal-cell cancer of skin, 471
epithelioma, 214
Basal-metabolic diet before operations in diabetes, 123
Basal-squamous-cell epithelioma, 214
Baseball finger, 301, 1296
Basedow's disease, 479
Basilar meningitis, 688
Bassini's operation for inguinal hernia, 1186

Basting-stitch method of aseptic intestinal anastomosis, 1090
Battle-Jalaguier-Kammerer incision, 972
Battle's incision for appendectomy, 1114
sign, 37
in fractures, 261
of base of skull, 678
Baudouin, 873
Baughman, 55
Bavarian splint, 531
Bayliss gum-acacia solution as substitute for blood-transfusion, 93
gum-salt solution in shock, 116
Bayonet wounds of chest, 879
Bazin's disease, 30, **467**, 470
Beasley-Cannaday extension tongs, *268*
Beates, 499
Beatie, 979
Beatson's operation, 910
Bechterew, 767
Beck's bismuth paste, 993
No. 1, 139
No. 2, 139
operation for balanic hypospadias, 1278
Becquerel, 76
Bedbug, bites, 60
giant, bite, 60
Bednar's aphthæ, 822
Bed-sore, 30, *31*
Beer-test of gonorrhea, 1260
Bell, external respiratory nerve, injury, 448
Bell's palsy, 731
treatment of cancer, 219
Belt, Momburg's, 82
Bence-Jones proteinuria in myeloma, 252
Bending fractures, 257
of skull, 671
Bennett, 323
Bennett's fracture, 299
Benzocain, local anesthesia by, 560
Benzoxy - dimethylamino - methyl - dimethylamino - methyl-dimethyl- aminobutane hydrochlorid, local anesthesia by, 559
Benzoyl - dimethylamino - methylpropanol hydrochlorid, local anesthesia by, 559
Berger's interscapulothoracic amputation, 653
Berti, 1028
Bertrand, 56
Betel nut cancer, 206
Bevan, 856
Bevan's incision, 974
operation for undescended testicle, 1281
Beye, 938
Beyea's operation, 1048
in gastroptosis, 1027
Bezoar, 1003
Bezoars in stomach, 1003
Biceps muscle, right, rupture of, from muscular action, 382
Bichlorid of mercury as disinfectant, 134
solution as wet or moist dressing for wounds, 50
Bicipital rib, 847
Bier, 273, 533, 578
Bier's passive hyperemia in non-union of fractures, 273
treatment of inflammation, 23, 24
Bifid ensiform sternum, 872
tongue, 820
Bifurcation of hand, 1292
Big heel, 1304
jaw, 170
nose, 176
Bigelow, 1253
Bigelow's lithotrite, *1254*
treatment of backward dislocation of hip, 369
of forward dislocation of hip, 370
Bile, stagnation of, as cause of gallstones, 1133
starvation, treatment, 1121
white, in gall-bladder, 1131
Bile-ducts, 1146
anomalies, 1146
Bile-ducts, inflammation, 1149
injuries, 1147
stones in, 1149
Courvoisier's law, 1149
Bile-infection of gall-bladder, 1135
Bilharzia hæmatobia, 62, 63
in bladder, 1256
japonica, 63
mansoni, 63
Bilharzial colitis, 63
Bilharziasis, 62
Biliary cirrhosis, hypertrophic, 1127
colic, appendicitis and, differentiation, 1103
disease in chronic appendicitis, 1106
tests for, 1119
fistula, 958
external, 1145
operations for, 1146
infection of gall-bladder, 1135
jaundice, 1128, *1129*
passages, operations on, position for, *1138*
system, 1119
operations on, treatment after, 594
Bilirubin-calcium gall-stones, 1131
Bilirubinuria, 1120
Billiard-ball testis, *1285*
Billroth, 383, 1045
Billroth I gastrectomy, *1038*, 1052
modified, *1048*, *1050*
Billroth II gastrectomy, *1038*, 1052
Billroth's anastomosis, modifications of, *1043*
Binocular hydrocele, 1282
Binocle bandage, *524*
Biologic disinfectants, 129
Bipp, 138
Bird-face, *619*, 805
Birth-mark, 194, 799
strawberry, 469
Birth-palsy, brachial, 447
Bishop, 90
Biskra button, 178
Bismuth injections in syphilis, 166
oxyiodid, 139
paste No. 1, 139
No. 2, 139
in empyema, 917
powders, 139
for wounds, 48
subgallate, 139
subiodid paste, 139
Bismuth-iodoform-paraffin paste, 138
Bistouries, 595
Bite-block, McKee-McCready, *925*
Bites of Annelida, 61
of Arachnidia, 60
of Argas moubata, 60
persicus, 60
of bedbug, 60
of Boöphilus bovis, 60
of fleas, 59
of insects, 58
of itch-mite, 60
of Ixodes, 60
of leeches, 61
of lice, 60
of scorpions, 60
of spiders, 60
of tarantula, 60
of ticks, 60
of wood-lice, 60
snake, 56. See also *Snake bite.*
Bitrochanteric test in fracture of base of neck of femur, 310
Black and blue skin, 37
hairy tongue, 821
Blackfan, 509
Black-water fever, 1224
Bladder, 1248
angioma, 1257
anilin cancer, 206
animal parasites in, 1256
Bilharzia hæmatobia in, 1256
calculus, 1252
cancer, 1257
secondary, 1258
congenital anomalies, 1246
cysts, 1257
diverticula, 1250
congenital, 1250
exstrophy, 1248
extroversion, 1248
Bladder, fibroma, 1257
filaria in, 1256
foreign bodies in, 1251
hemorrhage from, treatment, 89
hernia, 1182
inflammation, 1254
irrigation, Janet's method, 1256
myoma, 1257
myxoma, 1257
neck of, infection, 1255
obstructing bar, treatment, 1275
osteoplastic reconstruction, for exstrophy, 1250
papilloma, 1257
perforation, chronic, 1251
rupture, 961, **1250**, 1251
in fracture of pelvis, 302
sarcoma, 1258
sound, introduction of, *1273*
stammering, 1248
stone in, 1252
tumors, 1257
wounds, penetrating, 1251
Blair, Bollin, and Angle, 805
Bland-Sutton, 205
Blastomycetes of neck, 856
Blastomycetic dermatitis, **176**, 468
osteitis, 239
Blastomycosis, 176
cutaneous type, 176
of bones, 239
of skin, 468
systemic, 176
treatment, 177
Blebs, hemorrhagic, in fractures, 261
Bleeder's disease, 89
joint in hemophilia, 331
Bleeding, 418
Blepharospasm, 734
Blind boil, 464
Blindness in tumors of brain, 715
Blistering, 516
Blisters, 21
blood-, 36
Block anesthesia, 554
extradural, 575
spinal, Ayer's, 745
Blocked pleurisy, 918
Blood clot, 84
composition, 77
extravasation of, 78
in anesthesia, 539
in urine, 1223
injection, in non-union of fractures, 273
method by which lymph reaches, 419
removal, from veins, 418
suffusion, 78
sugillation, 78
tumor, 37
urea test of kidney function, 1226
Blood-blisters, 36
Blood-cysts of neck, 857
Bloodgood, 187, 213, 252, 253, 896, 1061
Blood-letting, 515
Blood-pressure and ligation of arteries, 624
effect of spinal anesthesia upon, 561, *562*, *563*
fall in, during spinal anesthesia, 572
in anesthesia, 536
Blood-stream, infection through, 126
Blood-transfusion, 90
apparatus methods, 93
Bayliss gum-acacia solution as substitute, 93
citrated method, 91
direct method, 92
in pernicious anemia, 1161
in shock, 116
intraperitoneal, 508
Kimpton-Brown method, 92
Lee's agglutinin test in, 91
Linderman's method, 92
methods, 92
reactions from, 91
Scannell's apparatus, 93
substitutes, 93
syringe method, 92
typing, 91
Unger apparatus, *92*
whole blood, 91
Blood-vessels, diseases, 391

Blood-vessels, hardened, introduction of, for ascites, 994
inflammation, 105
wounds, 46
Blow bottles, *921*
Blue dome cysts, 896
Blue-sclera syndrome, 225
Blumer's rectal shelf, 1037
Blunt dissectors, 596
Boeck's multiple sarcoid, 469
Boil, 141, 464
Aleppo, 178
Bagdad, 178
blind, 464
Delhi, 178
gadfly, 59
gum-, 807
of chest, 880
of scalp, 667
treatment, 142
Bollin, Angle, and Blair, 805
Bollinger, 170
Bond, 1135
Bond's currents, 1053
splint, *295*
Bone cyst of humerus, *221*
predisposing to fractures, 259
drill, 190, 273, 383
felon, subperiosteal, 1298
lacrimal, fracture, 275
malar, fracture, 275
metastasis to, from cancer of breast, 901
navicular, double, 1291
rider's, 190, 383
Staphylococcus pyogenes in, 141
traction clamps, 269
transplantation, 619
Bone-curet, Bruns', 600
Bone-cutting forceps, 598
Liston's, *597*
instruments, 598
Bone-graft in non-union of fractures, 274
in ununited fracture of neck of femur, 308
Bone-holding forceps, 598
Bone-inlays for fractures, 271
Bone-peg, intramedullary, in fractures, *273*
Bones, actinomycosis, 239
aneurysm, 244, **253**
benign giant-cell tumor, 252
blastomycosis, 239
brittle, 224, 225
cancellous, outgrowths, 241
carcinoma, secondary, 254
caries, 230
carpal, dislocations, 362
old, 364
fracture, 298
circumscribed abscess, 236
coccidioidal granuloma, 239
cystic disease, 228
cysts, 228
echinococcus cyst, 239
endothelioma, 249
fibroma, 243
gouge, 235
gumma, 238
gunshot wounds, predisposing to fractures, 259
hydatid disease, 239
hypernephroma, 254
imperfect development, conditions characterized by, 223
infections, 230
inflammation, 230
predisposing to fractures, 258
malignant tumors, secondary, 254
marble, 225, **226**
metacarpal, dislocations, 364
miliary tuberculosis, 236
mycetoma, 239
nasal, fractures, 274
of feet, osteogenic sarcoma, 246
overgrowth, conditions characterized by, 227
Paget's disease, 190, **227**
pulsating hematoma, 253
regeneration, in fractures, 260
sarcoma, 244
classification, 245
secondary, 254
Bones, softening, 226
diffuse, 237
supernumerary, of foot, 1304
of wrist-joint, 1290
surgery, 223
syphilis, 238
tuberculosis, 236
caseous, 236
tuberculous abscess, chronic, deep, 238
tumors, 241, 242
differential diagnosis, 253
malignant, secondary, 254
nomenclature, 241
predisposing to fractures, 259
Bony ankylosis, 342
defects of lower extremity, 1300
fusion of radius and ulna, 1290
Boöphilus bovis, bite of, 60
Bootlace intestinal suture, 1088
Boric acid, 137
and iodoform dusting-powder, 138
solution for wet or moist dressing, 50
alcohol, 137
Botryomycosis hominis, 466
Bottle operation for hydrocele, 1283
Bottles, aspirating, Jackson's, *925*
blow, *921*
Wolff's, *921*
Bouba braziliana, 179
Boubas, 167
Bougard's paste in cancer, 216
Bougie, Tucker's, 869
Bouginage, esophageal, 869
Bowen's precancerous dermatosis, 209
Bow-leg, 1303
Bowman, 275
Boyer's operation for fissure in ano, 1212
Braces, 532
Brachial artery, aneurysm, *407*
digital compression, 80
ligation, 632
birth-palsy, 447
fibrositis, 382
neuralgia, 434
palsy in anesthesia, 540
plexus anesthesia, 577
infraclavicular rupture, 446
lesions, 446
paralysis, 447
from cervical rib, 448
lower-arm type, 447
supraclavicular rupture, 446
Brachycephalic skull, 669
Brachydactylism, 1289
Brachyphalangism, 1289
Bracket's operation for ununited fracture of neck of femur, 308
Bradford frame, *771*
modified, 1302
Bradycardia of spinal anesthesia, *563*
Brain, 687, **690**. See also *Cerebral*.
abscess, 709. See also *Abscess of brain*.
compression, 701. See also *Cerebral compression*.
concussion, 700
contusion, 707
cortical centers, 690, *691*, *692*
edema, 707
endothelioma, 717
fibroma, 717
fungus, 724
glioma, 714, 717
hemorrhage from, 701
control, 705
extradural, 706
in newborn, 707
treatment, 89, **704**
hernia, 723
in anesthesia, 538
laceration, 707
occipital lobe, 690
removal, effect of, 690
sarcoma, 717
sinuses, hemorrhage from, control, 706
syphilitic gumma, 717
tuberculoma, 717
tumors, 714
craniotomy, 721
decompression operation, 718
Brain tumors, location, **714**
lumbar puncture, 721
spinal puncture, 721
treatment, 718
ventricular tap, **719**
wet, 121
Brams, 1284
Branchial cancer, 858
cyst of neck, *221*
dermoids, 220
fistula, 845
Branchiogenic cancer, 858
cysts, 856
Brandt's gastroplication, 1048
for gastrectasia, *1051*
Brasdor, 403
Brasdor's operation for aneurysm, *403*
Brauer, 878, 945
Brauer and Friedrich, 940
pneumolysis, 941
Brault, 461
Braun, 558, 578, 1045
Braun's operation of ligation of ileocolic vein, 1124
Breach, definition, 1165
Breast, 888
abscess, *889*, **891**
absence, 888
adenoma, 897
amputation, for cancer, *906*, *907*, *908*, *909*, *910*, *911*
atrophic scirrhous cancer, 903
caked, 891
cancer, 898. See also *Carcinoma of breast*.
chicken-, 872
colloid cancer, 899, **904**
congenital anomalies, 888
cystadenoma, 896
cystic adenoma, 897
cancer, 904
cysticercus disease, 896
cystosarcoma phyllodes, 897
proliferum, 897
cysts, 893, **895**. See also *Cysts of breast*.
encephaloid cancer, 899, **903**
fibro-adenoma, 897
fibromyoma, 897
funnel-, 872
gelatinoid cancer, 899, **904**
hernia, plastic operation for, 910
hypertrophy, 188, **889**
hypoplasia, 888
infantile, 888
inflammation. See *Mastitis*.
intracanalicular fibro-adenoma, 897
larvæ of tapeworms in, 896
medullary cancer, 899, **903**
multiple, 888
myxoma intracanaliculare, 897
Paget's disease, 209
periductal fibroma, 896
pigeon-, 223, **872**
plastic operations on, 910
resection, 910
sarcoma, 897
scirrhous cancer, 899, *900*, *901*
serocystic disease, 897
traumatism, 889
tuberculosis, 894
tubular adenoma, 897
withering scirrhous cancer, 903
Breda's disease, 179
Brentano, 952
Brewer, 466
Brick-maker's anemia, 62
Brick's colostomy bag and belt, *1090*
Brilliant green, 138
Brittle bones, 224, 225
nails, 473
Broca's area, 690
rule, 814
Brödel's line, 1242
Broders' index of malignancy of cancer, 208
law, 244
Brodie's abscess, 231, **236**
disease, 896
joint, 342
Broken back, 764
Bromethylmethyl chloroformate, effects of, 71

Bromin solution, as wet dressing for wounds, 50
Bronchial fistula, 934
pneumonia, 935
acute tuberculous, 935
subacute tuberculous, 935
Bronchiectasis, 833, **931**
acute, 931
apiotomy in, 932
artificial pneumothorax in, 932
bronchoscopic treatment, 931
bronchostomy in, 932
cautery pneumectomy in, 933
chronic, 931
inhalations in, 931
lobectomy in, 933
operations, 932
pneumectomy in, 933
postural drainage, 931
thoracoplasty in, 932
Bronchitis, 833
anesthesia in, 537
arachidic, 833, 924
peanut, 924
vegetal, 833, **924**
Bronchocele, 203, 476
simple, 479
Bronchocutaneous fistula, 934
Bronchopleural fistula, 934
Bronchopneumonia in anesthesia, 535
Bronchoscope, Jackson's, *925*
Bronchoscopic lung-mapping, 923
Bronchoscopy, 835
in bronchiectasis, 931
method of supporting head, *925*
Bronchostomy in bronchiectasis, 932
Bronchotomy, 844
left, 844
right, 844
Bronchus, adenocarcinoma, 936
dilatation, 930, 931
foreign body in, 833, **924**
abscess from, 928
lymphosarcoma, 936
operations, positions for, *932*, *933*
tack in, *924*
tumors, radium treatment, 937
Brophy's elevator, *789*
needle, *789*
operation for cleft-palate, 787, *788*
Brown, Kerr, and Coffey, 947
Brown-Buerger cystoscope, *1224*
Brown-Séquard, 621
syndrome, 433, **744**, 776, 777
reversed, 778
Brugsch, 491
Bruises, 36, 37
stone, 387
Bruit, aneurysmal, 399
Brunn and Pearl, 1034
Bruns, 231
Bruns' bone-curet, *600*
Brush burn, 36, 40, 66
Bryant's sign in dislocation of scapula, 354
triangle in fracture of neck of femur, 306
Bubo, 168
indolent, 161
parotid, 828
Bubonocele, 1177
Buckley, 463
Buck's extension in fracture of neck of femur, 307
Buena, 167
Buerger-Brown cystoscope, *1224*
Buerger's disease, **105**, 108, 392
Buerki's cock-up splint, *451*
Bug, harvest, 60
red, 60
Bulimia, 1033
Bull and Pritchett, 110
Bullæ, 21
Bullet wounds of chest, 879
treatment, *45*
Bunge's amputation, 641
Bunion, 205, 390, **1311**
Burdach, 777
Burgundy nose, 798
Burkhardt, 553
Burnol for burns, 69
Burns, 66
actinic, 66
ambrine for, 69
Burns, antitetanic serum in, 70
brush, 36, 40, 66
burnol for, 69
carron oil for, 69
chemical, 66, **70**
Dupuytren's classification, 66
electrical, 66, **73**
fifth degree, 68
first degree, 66
stage, 68
fourth degree, 67
from mechanical friction, 66
metabolic changes in, 66
of chest wall, 876
of epiglottis, 70
of esophagus, 863
of face, 793
of glottis, 70
of larynx, 837
of pharynx, 70
of stomach, 1002
stricture following, 1003
of tongue, 70
of trachea, 837
pathology, 66
picric acid in, 137
prognosis, 69
radiation, 73
radium, 76
resin cerate for, 70
Roentgen-ray, 74
second degree, 67
stage, 68
shock from, treatment, 69
sixth degree, 68
stage of reaction and inflammation, 68
of shock and depression, 68
of suppuration and exhaustion, 69
symptoms, 68
tannic acid for, 69
third degree, 67
stage, 69
treatment, 69
varieties, 66
Burrow's solution for wet or moist dressing, 50
Burrs, Doyen's, for perforating skull, *704*
Burs, 599
Bursæ, acromial, inflammation, 390
adventitious, 387
cystic, of neck, 857
diseases, 387
fibroma, 390
giant-cell tumor, 390
hematoma, 387
iliopsoas, inflammation, 390
inflammation, 387
ischial, inflammation, 390
melon-seed bodies in, 387
myeloma, 390
new, 387
olecranon, inflammation, 390
popliteal, inflammation, 390
prepatellar, inflammation, 390
sarcoma, 390
serous distention, 21
subcrural, inflammation, 390
subscapular, inflammation, 390
tumors, 390
Bursal hydrops, 387
hygroma, 387
Bursitis, 387
acute, 387
calcaneal, 387
posterior, 388
chronic, 387
occupation, 387
plantar, anterior, 389
pre-acetabular, femoral hernia and, differentiation, 1197
inguinal hernia and, differentiation, 1184
serous, 21
subacromial, 389
subdeltoid, 389
Dawbarn's sign, 389
with calcification, *388*
trade, 387
Bursopathy, syphilitic, of Vernieul, *389*
Bursting fractures, 257
of skull, 672, *673*
Busse, 856
Butcher's wart, 467
Butesin picrate, local anesthesia by, 561
Button sutures, *604*
Buttons, 175
Butyn, local anesthesia by, 557

Cable graft, 443
Cabot's posterior wire leg-splint, *267*
Cachar sore, 179
Cachexia strumipriva, 478
thyreopriva, 478
Caked breast, 891
Calcaneal bursitis, 387
posterior, 388
Calcaneus, fracture, 326. See also *Fracture of calcaneus.*
Calcium deficiency, gastric tetany in, 1031
oxide, 140
Calcium-carbonate gall-stones, 1131
Calculous anuria, 1232
Calculus of seminal vesicles, 1277
pancreatic, 1153
preputial, 1279
prostatic, 1275
renal, 1228
salivary, 827
ureteral, 1244
urethral, 1259
vesical, 1252
Caldwell-Luc operation for dental cysts, 815
Callaway's sign in dislocation of scapula, 354
Callositas, 205, **462**
Callosity, 462
Callous ulcer, treatment, 32
Callus, 205
formation in fractures, 259
subungual, 474
tendon-, 1296
Calmette, 56, 58
Caloric test of Bárány, 694
Calot, 772
Calot's fluid, No. 1, 139
No. 2, 139
paste, No. 1, 139
No. 2, 139
treatment of tuberculous lymphadenitis, 855
Calvé-Perthes disease, 239, **240**
Cammidge, 1154
Cammidge's reaction in pancreatic disease, 1151
Camp, 509
Campbell's operation on hip-joint, 371
Camper's facial angle, 670
Camus, 490
Canal of Nuck, hydrocele, 1282
Cancellous bone, outgrowths, 241
osteoma, 242
Cancer, 205. See also *Carcinoma.*
Cancroid, 210
of skin, 471
ulcer, 214
Cancrum oris, 110
Cannon, 40, 112, 113
Cannula, Hahn's, 843
Konig's, 843
Trendelenburg's, 843
Capeline bandage, *524*
Capillary circulation test for impending gangrene, 94
drainage, 51
hemorrhage, 77
treatment, 88
nevus, 469
tubes for ascites, 994
Capital epiphysis of femur, separation, 309
Capitate fracture, 299
Caprokol in urinary infections, 128
Capsulorrhaphy, 345
Caput medusæ, 1126
obstipum, 848
quadratum, 224
succedaneum, 664
Carabelli, tubercle of, 163
Carbohydrate test in hepatic disease, 1120
Carbolic acid as disinfectant, 133
gangrene, *108*, 109
Carbon dioxid anesthesia, 552

Carbuncle, 141, **465**
anthrax and, differentiation, 465
of chest wall, 880
of scalp, 667
of upper lip, 466
treatment, 142
Carcinoma, 205
adenoid, of lip, 802
anilin, of bladder, 206
atrophic scirrhous, of breast, 903
basal-cell, of skin, 471
treatment, 472
betel nut, 206
branchial, 858
branchiogenic, 858
Broders' index of malignancy, 208
chimney sweeps', 1287
clinical symptoms, 209
colloid, 210
of breast, 899, **904**
of rectum, 1218
columnar-cell, 206, 215
comparative pathology, 208
cylindrical-cell, 206, **215**
cylindromatosa, 210
cystic, of breast, 904
en cuirasse of breast, 900, *903*
encephaloid, 207, **208**
of breast, 899, **903**
epidermoid, 210
etiology, 206
flat-cell, 206, **210**
gelatinoid, of breast, 899, **904**
gelatinosum, 210
gland-cell, 206, **210**
gum, 210
hairy matrix, 471
infection theory, 207
irritation theory, 206
juice, 207
kangri, 213
lenticulare, 214
lupus, 208
medullary, **199**, 207
of breast, 899, **903**
of rectum, 1218
melanotic, 207
molle, 208
mulespinner's, 1287
myxomatodes, 208
of abdominal wall, secondary, 971
of anus, 1218
of appendix, 1118
of bladder, 1257
secondary, 1258
of bones, secondary, 254
of breast, 898
Beatson's operation, 910
erythema in, *902*
inoperable, treatment of, 909
lymphatic involvement, **899**, 901
metastasis to bone, 901
to internal organs, 903
pig-skin, *903*
skin changes, 900
incisions, *905*, 908
spread, 899
varieties, 899, **903**
of cardia, inoperable, *1040*
of cecum, *1080*, *1082*
of chest, 887
of colon, 1081, *1082*
diarrhea in, 1082
localization, *1081*
of esophagus, 869
of face, 802
of gall-bladder, *1148*, 1149
cholecystitis and, differentiation, 1142
of intestines, stricture in, 1067
of kidney, 1241
of larynx, 841
of liver, 1128
of lower jaw, 816
of lung, 936
secondary, 937
of lymph-glands, 428
of neck, 858
of pancreas, 1155
of parotid, 829
of pelvic colon, *1219*
of penis, 1280
of peritoneum, secondary, 996
of pituitary, 496
Carcinoma of pleura, secondary, 918
of prostate, 1276
of rectosigmoid, Coffey's operation, 1221
of rectum, 1218
formation of abdominal anus in, 1220
of combined sacral and abdominal anus in, 1221
of lumbar anus in, 1220
of sacral anus in, 1220
Kraske's operation, 1220
lower, Coffey's operation, 1221
perineal excision, 1220
sacral operation, 1220
upper, Coffey's operation, 1221
vaginal excision, 1220
of sigmoid, *1083*
of small intestine, 1081
Courvoisier's syndrome, 1081
of stomach, 1035, *1036*, *1037*
conditions contraindicating excision, *1042*
encephaloid, 1037
extension, 1036
hematemesis in, 1024
leather-bottle stomach in, 1036
medullary, 1037
palliative operation, 1044
partial gastrectomy for, 1043
peptic ulcer and, differentiation, 1017
perforated peptic ulcer and, differentiation, 1011
prognosis, 1041
secondary to gastric ulcer, 1012
site, 1036
of thyroid gland, 484
of tongue, 823
Kocher's operation, 824
radium for, 824
Syme's operation, 824
Whitehead's operation, 824
of umbilicus, 959
of upper jaw, 816
paraffin, 206
pathology, 207
precancerous lesions, 208
prickle-cell, 210
scar, 213
scirrhous, 297
of breast, 899, *900*, *901*
of rectum, 1218
seat, 205
sebaceous, 214
simplex, 206
skin, 210
spider, 194
of face, 799
spinocell, 210
squamous-cell, 206, **210**
tar, 206
telangiectodes, 210
treatment, 216
tuberosum, 214
with intestinal fistula, 1073
withering scirrhous, of breast, 903
varieties, 206
Carcinosis, acute miliary, 208
Carden's amputation of leg, 658
Cardia, carcinoma of, inoperable, *1040*
divulsion, 1046
Cardiac circulation, control of, 949
massage, 502, **948**
Babcock's digital method, 948, *948*
subdiaphragmatic, 948
transdiaphragmatic, 948
transthoracic, 948
resuscitation, 947
Cardiodiosis, 1046
Cardiolysis, 945
Cardiorrhaphy, 944, **948**
Cardiospasm, *865*, 866
Cardiosymphysis, 945
Cardiovascular disease in operations, 585
Cargentos, 136
Caries, 100
dental, 807
fungosa, 230
necrotica, 230
of bone, 230
sicca, 230
tuberculous, 237
Caries, superficial, 237
suppurativa, 230
Carliss and Gross, 1154
Carlsbad, 1133
Carman, 340, 865, 866, 867, 870, 999, 1007, 1011, 1013, 1025, 1028, 1029, 1034, 1035, 1040, 1069, 1079, 1082
Carotid artery, common, digital compression, 80
right, ligation of, 626
digital compression, 80
external, ligation of, 627
internal, hemorrhage from, 706
ligation of, 629
gland, endothelioma, 859
tumors, 859
sheath, perivascular infection, 853
Carpal bones, dislocation, 362
old, 364
fracture, 298
scaphoid, dislocation, 362
Carpus, dislocation, **362**, 363
forward, 362
Carrel, 620, 621, 946
Carrel-Dakin treatment of gunshot wounds, 54
of wounds, 53
Carrel's needles, 602
Carron oil, 140
for burns, 69
Carslow, 979
Cartilage, costal, fracture, 278
internal semilunar, subluxation, 375
knives, 595
laryngeal, absence or hypoplasia, 833
dislocation, 837
Cart-wheel fracture, 317
Case, 1055
Caseation, 100
Caseous pneumonia, 935
tuberculosis, 159
of kidney, 1236
tuberculous peritonitis, 991, **992**
Castellani, 161, 167
Cat flea, 61
Catarrh, 21
mucopurulent, 21
mucous, 21
purulent, 21
Catarrhal appendicitis, chronic, *1106*, *1107*
cholecystitis, chronic, 1134
inflammation, 21
Caterpillars, irritation of skin from, 59
Cathelin, 575
Catheter, coude woven gum elastic, *1274*
fever, 1271
metal, *1274*
mushroom, *1258*
Pezzer, 1258
types, *1247*
Catlin, 595, *596*
Cattell, 115
Catton, 509
Cauda equina, growths, 758
injuries, 457
involvement, in injuries of spine, 743
Caudal anesthesia, 575
Causalgia, 430, **444**
Caustic issue, 516
spark in cancer, 217
Cauterization, division or destruction of tissue by, 597
in arrest of hemorrhage, 83
steam, 597
Cautery, actual, 516
in cancer, 216
Paquelin, 597
Percy electric, 597
pneumectomy in bronchiectasis, 933
Cavernositis, fibrous, 1280
Cavernous angioma, 193, **194**
of neck, 857
hemangioma, 469
lymphangioma, 197
of face, 800
of neck, 857
sinus thrombosis, 712
Cecal colostomy, 1090
hernia, sacless, 1182
Cecocele, 1167
Cecopexy, *1089*

Cecostomy, Phillip's method, 1094
Cecum, blood-supply, *1096*
  carcinoma, *1080*, *1082*
  mobile and ptosis of ascending colon, Waugh's operation, *1089*
Cell multiplication in inflammation, 20
Cells, character, 25
  giant-, 26
  lymphadenoma, 425
  mast-, 26
  plasma-, 26
Cellular death, 100
  exudation, 20
Cellulitis, 144
  cervical, diffuse, 854
  of forearm, 1299
  of floor of mouth and neck, 853
  of neck, 854
  of scalp, 668
  palmar, 1298
  periurethral, complicating urethral stricture, 1270
Cellulocutaneous erysipelas, 144
Celsus, 641
Cementoma, 205
Central dislocation of hip, 367
Cephalalgia complicating skull injuries, 708
Cephalhematoma, 664
Cephalhydrocele, traumatic, 667
Cephalic index, 669
  tetanus, 150
Cephalocele, 670
Cercomonas intestinalis, 65
Cerebellar abscess, 710
Cerebellopontile angle, tumors, symptoms, 716
Cerebellum, partial removal, effects, 692
Cerebral. See also *Brain*.
  abscess, 709
  air-embolism, 933
  compression, 701
    alcoholism and, differentiation, 703
    apoplexy and, differentiation, 703
    cerebral embolism and, differentiation, 703
    coma and, differentiation, 703
    first stage, 702
    opium poisoning and, differentiation, 703
    second stage, 702
    status epilepticus and, differentiation, 703
    third stage, 703
  concussion, 700
  contusion, 707
  edema, 707
  embolism, cerebral compression and, differentiation, 703
  fungus, 724
  hernia, 723
  irritation, 707
  laceration, 707
  nerve lesions in fracture of base of skull, 679
  shock, 700
  sinuses, hemorrhage from, control, 706
    infective thrombosis, 711
    venous, injury to, 707
  spasticity, peripheral operations to relieve, 783
  tumors, 714. See also *Brain, tumors*.
Cerebrospinal fluid, 738
    amount, 701
    chemical changes, 746
    chemistry, 738
    circulation, 738
    coagulation, 746
    cytology, 738
    escape in fracture of base of skull, 679
    Nonne-Apelt test, 746
    Nonne's test, 746
    Pandy's test, 746
    pressure, 738
    Queckenstedt's test, 738, **744**
    yellowish, 746
  meningitis, 688, 773
Cervical auricles, 845
  cellulitis, diffuse, 854
  esophagostomy, 871
  occipital neuralgia, 434
Cervical rib, 108, **846**
    paralysis of brachial plexus from, 448
    treatment, 848
  sympathectomy, 947
  sympathetic nerve lesions, 737
  tuberculous lymphadenitis, 424
  vertebræ, dislocation, 762
    lower, abscess of, 772
    upper, abscess of, 772
Cestodes, 64
Chain ligature, 605
Chancre, 161
  characteristics, *162*
  of face, 796
  of finger, 1299
  of lip, *796*
  of tongue, 822
  soft, 168
Chancroid, **168**
Chapin and McCoy, 156
Charcot, 340
Charcot's intermittent fever, 1149
    in gall-stones, 1133
  joint, 340
    in children, 340
  knee, *339*, 340
Charrier's saw, 598, *599*
Chase, 362
Chassaignac, phlegmon of, 853
Chassaignac's tubercle, 80, 627
Chauffard-Minkowski type of hemolytic icterus, 1160
Chauffeur's fracture, 295
Cheek, auricular appendages, 735
  congenital malformations, 735
  defect in, closure, *612*
  lymphangioma, 801
Cheesy necrosis, 100
Chemical astringents in arrest of hemorrhage, 83
  burns, 66, **70**
  coagulants in arrest of hemorrhage, 83
  depilatories, 463
  disinfection, 129
  erythema, 67
  gangrene, 109
  local anesthetics, 556
Chemistry of cerebrospinal fluid, 738
Chest, alterations in scoliosis, *768*
  aspiration, 918
  atheroma, 884
  barrel-, 873
  concussion, 875
  constricted, 873
  contusions, 874
  corset, 873
  fissure, 873
  flat, 873
  funnel-, 872
  hour-glass, 873
  injuries, 874
  malformations, acquired, 873
  operations, 918
  wall, 872
    actinomycosis, 883
    boils, 880
    burns, 876
    cancer, 887
    carbuncles, 880
    cavernous angioma, 885
    chondroma, 885
    chondrosarcoma, 885
    cold abscess, 882
    congenital anomalies, 872
    cysticercus, 884
    cysts, 884
    dermoid cysts, 884
    echinococcus cysts, 884
    enchondroma, 885
    entozoa, 884
    ephelides, 884
    epithelioma, 887
    fibroma, 884
    fibroneuroma, 884
    hemangioma, 884
    infections, 880
    keloids, 884
    lipoma, 884
    lymphadenitis, acute, **423**
    lymphangioma, 885
    moles, 884
    muscular defects, 873
Chest wall, myxoneuroma, 884
    nævus pilosi, 884
    osteosarcoma, 885
    sarcoma, 885
    sebaceous tumors, 884
    suppuration, 880
    syphilis, 883
    trichina, 884
    tuberculosis, 882
    tumors, **884**, 885
    verrucæ, 884
    von Recklinghausen's disease, 884
    warts, 884
    wounds, 876
      complications, 879
      contour, 876
      hernia of lung in, 879
      non-penetrating, 876
      open, 876
      penetrating, 878
      prolapse of lung in, 879
      sucking, 877
        treatment, 880
      tunnel, 876
      war, 879
Chevassu, 1286
Chevier, 415
Chiasserini, 783
Chicken-breast, 872
Chiene's test in fracture of neck of femur, 306
Chigre, 60
Chilblains, 73
  of face, 793
Childbirth, rectal ether analgesia in, 546
Chill, 22
Chimney sweeps' cancer, 1287
Chin, receding, *619*, 805
    correction, *619*
Chipault, 739, 772
Chisels, 600
  Macewen's, *235*
  Putti's, *344*
Chloral hydrate intravenous anesthesia, 553
Chloramin, 134
Chlorbutanol, local anesthesia by, 561
Chloretone, local anesthesia by, 561
Chlorid of lime as disinfectant, 134
Chlorin gas, effects of, 71
Chloroform anesthesia, 546. See also *Anesthesia, chloroform*.
  as counterirritant, 516
Chloroma, 201
  of skull, 686
Chloropicrin, effects of, 71
Choked disk in tumors of brain, 715
Cholecystectomy, *1138*, *1139*, *1140*, *1141*, *1142*, *1143*, *1147*, 1148
  recurrent colic after, operations for, 1146
Cholecystic colic, 1137
  infection as cause of gall-stones, 1132
Cholecystitis, 1134
  acute pancreatitis and, differentiation, **1141**, 1152
  appendicitis and, differentiation, **1103**, 1141
  chronic, 1142
    catarrhal, 1134
  diagnosis at operation, 1142
  diet in, 1143
  dyspepsia in, 1136
  gall-bladder colic in, 1137
  heart disease and, differentiation, 1139
  malignant disease of gall-bladder and, differentiation, 1142
  movable kidney and, differentiation, 1141
  operation, 1143
  papillary, 1142
  peptic ulcer and, differentiation, 1017
  perforated peptic ulcer and, differentiation, 1140
  purulent, 27, *1137*
  renal colic and, differentiation, 1140
  stages, 1136
Cholecystoduodenostomy, *1144*
  for hypertrophic biliary cirrhosis, 1127
Cholecystogastrostomy, *1145*
  for hypertrophic biliary cirrhosis, 1127

Cholecystogastrostomy, historical, 1046
Cholecystography, 1119
Cholecystostomy, *1143*
Choledochitis, 1149
Choledocholithiasis, 1149
Cholemia, congenital family, 1160
Cholesteatoma, 959
  of spine, *775*
Cholesterin gall-stones, 1130
Chondritis, laryngeal, 839
Chondroblasts, 25
Chondrodystrophia fœtalis, 227
Chondroma, **189**, 242
  of chest, 885
  of upper jaw, 816
Chondro-osteopolyarthritis, 339
Chondrosarcoma of chest, 885
Chopart, 644
Chopart's amputation of foot, 655
    Forbe's modification, 655
Chorda tympani, division, 851
Chordee, treatment, 1264
Chordoma, 193
Chordotomy, 782
  knives, Frazier's, *782*
Chorio-epithelioma, 215
  of testes, 1286
Chorioma of testes, 1286
Chromaffin bodies, 498
Chromocystoscopy test of renal function, 1226
Chromophobe struma of Cushing, 495
Churchill's inhalant, 841
Chutro's stirrup, 269
Chvostek's sign in gastric tetany, 1032
Chylangioma, 197
Chylomediastinum, 420
Chylorrhea, 419
Chylothorax, 420, **913**, 994
Chylous ascites, 420, **913**, 994
  cysts of mesentery, 996
Chyluria, 1224
Cicatricial horns, 798
  stricture of urethra, 1268
Cicatrix, carcinoma, 213
  disfiguring treatment, *55*
  formation of, 24
  horns, 205
  in amputation stumps, 643
  position, in amputation, 648
  secondary contracture, 54
Cicatrization, **24**
Cigarette-drain, *52*
Cinematic amputation, 642
Cineplastic amputation, 642
Circular amputation, 645
    modified, 646
  bandages, 521
Circulation, collateral, establishment of, after arterial ligation, 85
  of spinal cord, 741
Circulatory system in anesthesia, 536
Circumflex nerve, injuries, 449
Circumscribed traumatic aneurysm, 394
Cirrhosis of liver, 21, **1126**
    alcoholic, 1126
    Hanot's, 1127
    hematemesis in, 1024
    hypertrophic biliary, 1127
    Laennec's, 1126
    paracentesis abdominis in, 1126
    saphenous peritoneal anastomosis for, 1127
    splenectomy for, 1127
    Talma-Morrison operation, 1127
  of stomach, 1030
  of testis, 1285
  portal, 1126
Cirsoid aneurysm, 194, **396**, 799
    of scalp, 669
    treatment, 196
  neuroma, 190
Cisternal puncture, 779
Cisterna-magna puncture, 747
Citrated method of blood-transfusion, 91
Civiale's urethrotomy for stricture, 1269
Clacking jaw, 351
Clamp, bone traction, 269
  Doyen's gastric, 1045
  Dupuytren's, 1093
  Kelsey's hemorrhoidal, *1213*
Clamp, Kocher's, for gastrectomy, *1035*
Clamp-and-cautery operation for hemorrhoids, 1213
Clap, 1260
Clark, 217, 519
Clark's treatment in peritonitis, 982
Claudication, intermittent, 106
Clavicle, deficient, 872
  dislocation, 352
    acromial end, 353
    sternal end, 352
      backward, 352
      forward, 352
      upward, 352
  fracture, 279. See also *Fractures of clavicle.*
Clavicular cross, 280, *281*
Clavus, 205
  subungual, 474
Claw-hand, 447, **455**
Cleft hand, 1292
Cleft-palate, 784, **787**
  Brophy's operation, 787, *788*
  Davies-Colley's operation, 787, *788*
  early operation, 787
  Ferguson's operation, 787, *788*
  flap operation, 787, *788*
  Lane's operation, 787, *788*
  Langenbeck's operation, 787, *788*
  Smith's operation, 787
Clips, Michel, application, for cutaneous closure, *605*
  metal, 604, *605*
Cloaca, 1206
Cloquet's pectineal hernia, 1196
Closed fracture, 257
Clot, blood, 84
Cloudy swelling, 21
Clove-hitch knot, 606
Club motor amputation, 642
Clubbing of fingers, 229
Club-foot, 1307. See also *Talipes.*
Club-hand, 1291
Clutton's joint, 339
Clyers, 170
Coagulants in arrest of hemorrhage, 83
Coagulation, electric, in cancer, 217
  necrosis, 100
  of cerebrospinal fluid, 746
Coaptation splints, 531
Coat-sleeve resection of stomach, 1052
Cobbler intestinal suture, 1088
Cobra bite, 57
Coca, 219
Cocain, infiltration anesthesia by 557
  local anesthesia by, 556
Coccidia, 65
Coccidioidal granuloma, 239
Coccydynia, 434
Coccygalgia, 434
Coccygeal gland, 498
Coccygectomy, 304
Coccygodynia, **304**, 434
Coccyx, fracture, 304
  neuralgia, 304
Cochin leg, 461
Cochlear nerve, lesions, 734
Cock's operation for urethral stricture, 1269
Cock-up splint, 265
    Buerki's, *451*
    improvised, *296*
    Jones', *297*
      short, *299*
Coco, 167
Codivilla, 271
Codman, 362
Coffey, Brown, and Kerr, 947
Coffey's hammock-operation, 1048
  jejunostomy, 1048
  operation for carcinoma of lower rectum, 1221
    of upper rectum, 1221
  for exstrophy of bladder, 1249
  ureterocolostomy, 1244
Cohnheim's theory of tumors, 184
Cold abscess, **27**, 159, 772
    in tuberculous arthritis, treatment, 338
  of chest wall, 882
  treatment, 773
  application of, to body, effects, 72
  as counterirritant. 516
Cold, constitutional effects, 72
  disinfection by, 131
  in arrest of hemorrhage, 82
  local anesthesia by, 554
    necrosis from, 72
Cole, 1119
Colectomy, 1094
Coley's mixed toxins in osteogenic sarcoma, **244**, 249
  toxins in sarcoma, 202
Colic, abdominal, in intestinal obstruction, 1059
  biliary, appendicitis and differentiation, 1103
  cholecystic, 1137
  duct, 1149
  gall-bladder, 1137
  intussusception, 1062
  renal, appendicitis and, differentiation, 1103
    cholecystitis and, differentiation, 1140
    from calculus, 1230
  ureteral, appendicitis and, differentiation, 1103
    from renal calculus, 1230
Colitis, bilharzial, 63
  chronic ulcerative, *1069*
  ulcerative, *1070*
Collapse, 112
  tracheal, complicating operations on thyroid, 488
Collar-bone, dislocation, 352
  fracture, 279
Collargol, 136
Collateral circulation after ligation for arrest of hemorrhage, 85
Colles' fracture, 294
    Cotton-Lodor treatment, 295
  law in syphilis, 163
Colley-Davies' operation for cleft-palate, 787, *788*
Collins' hitch, *264*
  tongue-holding forceps, *540*
Colliquation cysts, 222
  necrosis, 100
Collitis, 1255
Colloid adenoma of thyroid gland, 483
  carcinoma, 210
    of breast, 899, **904**
    of rectum, 1218
  goiter, 476
Collupp, 489, 1032
Colon, ascending, prolapse of, Waugh' operation, *1088*, *1089*
    ptosis of, Waugh's operation *1089*
  bacillus, peritonitis due to, 876
  carcinoma, 1081, *1082*
    diarrhea in, 1082
    localization, *1081*
  dilatation of, gastric tetany in, 1031
    idiopathic, 1055
      congenital, 1055
  elongated, methods of shortening, *1086*
  evacuation of, in Hirschsprung's disease, 1057
  hypertrophy, 1055
  lipoma, *1080*
  pelvic, carcinoma of, *1219*
  polyposis, *1079*
  sigmoid, collateral circulation, 1093
Colonic irrigation, 505
Colopexy, 1088, *1089*
  for prolapse of rectum, 1215
Colostomy, 1090
  Brick's bag and belt for, *1090*
  cecal, 1090
  sigmoid, 1090
Columnar epithelioma, 206
Columnar-cell carcinoma, 215
Coma, 118
  alcoholic, 118
  cerebral compression and, differentiation, 703
  diabetic, 122
  drug-habit, 118
  epileptic, 118
  examination in, 119
  narcotic, 118
  postepileptic, 118
  postoperative treatment, 589
  uremic, 118

Combing of fibers of peripheral nerves, 438
Comedo, 220
Comminuted fracture, 256
Common carotid artery, digital compression, 80
duct, gall-stones in, 1133
obstruction, 1129
Courvoisier's law, 1149
operations on, 1146
Communis, obstruction of, 1149
Complicated fractures, 256
Compound fracture, 257
treatment, 271. See also *Fractures, compound.*
Compression, cerebral, 701. See also *Cerebral compression.*
fractures, **256**, 257
of calcaneus, 326
of vertebral bodies, 764
of peripheral nerves, 430
Concato's disease, 995
Concretio pericardii, 945
Concussion of brain, 700
of chest, 875
of larynx, 835
of spinal cord, 759
Condon's amputation of foot, 655
Conduction anesthesia, 534, **554**
Condy, 909
Condy's fluid, 137
Condyle of femur, separation, 312
Condyloma acuminata, 204
latum, **161**, 204
Congenital aneurysm, 394
angioma of liver, 1128
anomalies of abdominal wall, 957
of bladder, 1248
of breasts, 888
of chest wall, 872
of dentition, 785
of extremities, 1288
of gall-bladder, 1134
of heart, 943
of intestines, 1054
of jaws, 805
of kidney, 1222
of larynx and trachea, 832
of lung, 923
of muscles, 381
of neck, 845
of penis, 1277
of salivary glands, 825
of skin, 480
of skull, 665, **670**
of spleen, 1157
of stomach, 999
of testes, 1281
of thyroid gland, 475
of tongue, 819
of upper extremity, 1289
atresia of esophagus, 861
of intestines, 1054
contracture of fingers, 1293
cystic hygroma of neck, *845*
diaphragmatic hernia, 1204
dislocation of hip, 372. See also *Dislocation of hip, congenital.*
of patella, 374
lateral, 374
diverticula of bladder, 1250
of esophagus, 861
elevation of scapula, 1289
esophagobronchial fistula, 861
esophagotracheal fistula, 861
family cholemia, 1160
fissures and fistulæ of larynx and trachea, 832
fractures, 258
of femur, 315
of skull, 665
giant growth, 427
hernia, 1166
hydrocele, 1282
hernia and, differentiation, 1168
inguinal hernia and, differentiation, 1183
hydrocephalus, 694, *695*, *696*
hypertrophic stenosis of pylorus, 999
hypertrophy of foot, 1300
hypothyroidism, 478
idiopathic dilatation of colon, 1055
ileocecal cysts, 1076
inguinal hernia, 1178
Congenital injuries of skull, 664
lipoma, sacrococcygeal, 757
lymphangiectasis, 427
malformations of cheek, 785
of ears, 785
of esophagus, 861
of face, 784
of jaws, 785
of mouth, 784
of nose, 785
obstruction of duodenum, 1055
occlusion of urethra, 1258
phimosis, 1277
sacrococcygeal fistulæ, 758
sinuses, 758
serous cysts of neck, 856
stenosis of esophagus, 861
of intestines, 1054
of larynx and trachea, 833
stricture of intestine, 1066
of male urethra, 1277
of ureter, 1243
of urethra, 1258
syphilis in infancy, treatment, 166
talipes, **1307**, 1308
telangiectatic myxosarcoma of umbilicus, 959
torticollis, 848
total hemihypertrophy, 223
transposition of liver, 1121
umbilical hernia, 1198
weakness of abdominal wall, 964
Conjunctiva, preoperative treatment, 586
Connective tissue, regeneration, 25
Connell, 541
Connell's air-way tube, *543*
intestinal suture, 1087
Connor, 1045
Constipation, postoperative treatment, 593
Constricted chest, 873
Consumption, galloping, 935
Continuous sutures, *603*
Contracted tendo-calcaneus, 1304
Contracture, congenital, of fingers, 1293
Dupuytren's, 1295
muscular, 383
secondary, of scars, 54
Volkmann's, **105**, 289, 433, 1294
Contrecoup, point of, 700
Contused wounds, 36, **40**
wounds, treatment, 41
Contusion, 36
cerebral, 707
of chest, 874
of hip, 371
of larynx, 835
of liver, 1122
of muscles, 381
of peripheral nerves, 430
of shoulder, 358
of ureter, 1243
of urethra, 1259
Convulsive tic, 733
Conyers and Daniels, 169
Cooper's herniotome, 1170
treatment of dislocation of scapula, 357
Copher, 1134
Coproliths in intestines, 1061
Coracoid process, fracture, 281
Coral calculus in kidney, 1229
Corium, anatomy, 460
Corn, 205, **462**
Cornil, 181
Corning, 533
Cornu, 462
cutaneum, **205**, 462
humanum, 205
of face, 798
Coronal incision for operations on skull, *704*
Coronoid process of ulna, fracture, 291
Corpus cavernosum, inflammation, 1280
Corpuscles, pus-, 26
Corpuscular exudate, 20
Corrosion of esophagus, 863
theory of gastric ulcer, 1006
Corrosive sublimate as disinfectant, 134
Corset chest, 873
liver, 1121
Cortical centers of brain, 690, *691*, *692*
Cortical localization, 690
Costain's lymphaticostomy for jejunal toxemia in peritonitis, 984
Costal cartilage, fracture, 278
periosteotome, Babcock's, *920*
pseudarthrosis, 942
Costectomy, 920
regeneration of rib around drainage-tube after, *920*
Costotomes, 598, *920*
Cotton, 326
Cotton-Lodor treatment of Colles' fracture, 295
Coughlin's incision in breast cancer, *905*
Counterirritation, 516
in inflammation, 24
Coup de fouep, 1304
Courvoisier, 1045
Courvoisier's law, 1149
in carcinoma of pancreas, 1156
syndrome in carcinoma of small intestine, 1081
Cow-horn stomach, *1025*
Coxa plana, 240
valga, 372, **1301**
vara, 1301
congenital dislocation of hip and, differentiation, 373
Crab yaws, 167
Crab-apple-jelly nodules, 30, **160**
Crackling, emphysematous, in abdominal wall, 955
Cranial hemorrhage, treatment, 89
nerves, eighth, lesions, 734
eleventh, lesions, 736
fifth, lesions, 726
fourth, lesions, 726
lesions, 725
in fracture of base of skull, 679
ninth lesions, 735
paralysis, 725
seventh, lesions, 731
sixth, lesions, 730
tenth, lesions, 735
third, lesions, 726
twelfth, lesions, 737
unilateral division, 851
Craniocerebral topography, 693
Krönlein's method, 693
Craniotubes, 683
Craniotomy in tumors of brain, 721
osteoplastic, *716*, *717*
subtentorial, *720*, *721*, *722*, *723*, *724*
Cranium. See *Skull.*
Crater in gastric ulcer, 1007
Credé's method of preventing ophthalmia neonatorum, **136**, 148
Creolin as disinfectant, 133
Crepitus in fractures, 260
tendon, 384
Cresol as disinfectant, 133
solutions as wet or moist dressings for wounds, 50
Cretinism, 478, *491*
Cricotomy, 842
Crile, 90, 311, 487, 512, 533, 554, 577, 601
Crile's anoci-association in exophthalmic goiter, 482
method of incising superior thyroid artery, 629
theory of shock, 113
Crisis, Dietl's, appendicitis and, differentiation, 1103
gastric, treatment, 783
thyroid, in exophthalmic goiter, 482
Cross, clavicular, 280, *281*
Saint Andrew's, 525
Crossed bandage of eye, 524
Croupous exudate, 20
inflammation, 21
pneumonia, abscess of lung from, 928
Cruciate ligaments, rupture, 375
Crural nerve, anterior, injuries, 456
neuralgia, 434
Crushing forceps, Payr's, 1050
fractures, 256
of vertebral bodies, 764
wounds, 42
secondary infection in, treatment, 43
treatment, 38
Crutch palsy, 450
Cry, meningeal, 688

Cry, night, in tuberculous arthritis, 336
Cryer's elevator, *788*
Cryoscopy test of kidney function, 1226
Cubitus valgus, 289, **1290**
  varus, 288, **1290**
Cud-chewing, 1033
Culp, 1124
Cumol as disinfectant, 138
Curets, 600
Curie, 76
Curling's ulcer, 69
Currents of Bond, 1053
Curvature, spinal, 767
    lateral, 767
Cushing, 491, 599, 676, 681, 704, 946
  chromophobe struma of, 495
Cushing's cross-bow incision in brain tumors, 719, *720*
  intestinal suture, 1087
  rongeurs, *681*
  spinofacial anastomosis, 733
Cutaneous absœss of anus and rectum, 1207
  appendages, diseases, 460
  horn, 205
  leishmaniasis, 178
  nerve, lateral femoral, injuries, 457
  nevi, 193
  vein of leg, phlebolith in, *412*
Cutler, 543, 946
Cut-throat, 849
Cyanosis, traumatic, 874, *875*, *876*
Cyclical vomiting, 1033
Cylindrical epithelioma, 215
Cylindrical-cell carcinoma, 215
Cylindroma, 201
Cystadenocarcinoma of pancreas, 1153
Cystadenoma, 203
  of breast, 896
  of pancreas, 1153
  papilliferum, 203, **204**
Cystic adenoma, 203
    of breast, 897
  bursæ of neck, 857
  cancer of breast, 904
  disease of bone, 228
    of pancreas, 1153
  hygroma, 427
    congenital, of neck, *845*
  lymphangioma, 197
    of face, 800
  mastitis, 893
    chronic, 896
Cysticercus cellulosæ, 64
  cysts of face, 798
  disease of breast, 896
    of chest wall, 884
Cysticus, obstruction of, 1149
Cystitis, 1254
  acute catarrhal, 1254
    septic, 1254
  chronic, 1255
  colli, 1255
  from paraplegia, 1255
  gonorrheal, 1255
  pneumococcal, 1255
  tuberculous, 1256
  typhoidal, 1255
Cystocele, 1167
Cystoma, follicular, proliferating, 814
Cystosarcoma phyllodes of breast, 897
  proliferum of breast, 897
Cystoscope, Brown-Buerger, *1224*
Cystoscopy, 1225
Cysts, **219**
  acquired, 220
  adamantinous multilocular, 205
  Baker's, **331**, 343
    in osteo-arthritis, 341
  blood-, of neck, 857
  blue dome, 896
  bone, of humerus, *221*
    predisposing to fractures, 259
  branchial, of neck, *221*
  branchiogenic, 856
  chylous, of mesentery, 996
  colliquation, 222
  congenital, serous, of neck, 856
  cysticercus, of face, 798
  dentigerous, 205, **814**
    follicular, 814
    multilocular, 814
    radicular, 814
  dermoid, of chest, 884
Cysts, dermoid, of mediastinum, 938
    of scalp, 668
    of skull, 671
    of tongue, 823
  echinococcus, **64**, 222
    of abdominal wall, 222, *955*
    of bone, 239
    of chest wall, 884
    of face, 797
    of liver, 1124, *1125*
      hydrated thrill in, 1125
    of neck, 857
    of pancreas, 1153
    of skull, 684
    spinal tumors and, differentiation, 779
  embryonic, 219
  exudation, 220
  from chronic interstitial mastitis, 896
  hydatid, **64**, 222. See also *Cysts, echinoccus.*
  ileocecal, congenital, 1076
  lacteal, 896
  liquefaction, 222
  lymphatic, 427
  milk, 896
  monolocular, *220*
  mucous, of lower lip, **797**
    of tongue, 820
  multilocular, *220*
    of ovary, 203
  of bladder, 1257
  of bone, 228
  of breast, 893, **895**
    exudation, 895
    involution, 896
    larger ducts, 895
    parasitic, 896
    retention, 895
    serous, 896
    simple, 896
  of chest wall, 884
  of femoral canal, femoral hernia and, differentiation, 1147
  of heart, 947
  of intestines, 1076
    gas-, 1076
    mucous, 1076
  of joints, 343
  of kidney, 1239
  of liver, 1128
  of lung, 935
  of lymph-glands, 419
  of muscle, 384
  of ovary, tuberculous peritonitis and, differentiation, 992
  of pancreas, 1153, *1154*
    extirpation of, 1155
    marsupialization in, 1155
    Wohlgemuth's test, 1154
  of peritoneum, 996
  of pituitary gland, *492*
  of prostate, 1273
  of spleen, 1164
  of stomach, 1033
  of umbilicus, 959
  papilliferous, 204
  parasitic, 222
    of pancreas, 1153
  pilonidal, 468
  proliferative, of pancreas, 1153
  retention, of pancreas, 1153
    of sebaceous glands, 468
  sebaceous, 220, **468**
    of face, 801
    of neck, 857
    of scalp, 668
  serous, of scalp, 668
  thyroglossal, 845
  traumatic, of pancreas, 1151
  ventricular, of skull, 671
Cytology of cerebrospinal fluid, 738
Czerny, 1045
Czerny's intestinal suture, 1086, *1087*

D'Agote, 90
DaCosta, 409
Dactylitis, strumous, 237
  syphilitic, 339
Dahlgren, 598
Dahlgren's rongeur, *706*
Dakin's solution, 134
    for wounds, 53
Dakin's solution in empyema, 916
Dalater, 416
Dalrymple's sign in exophthalmic goiter, 237
Dancer's sprain, 381
Dandy, 509, 735
Dandy's method of pneumography, 746
  operation for hydrocephalus, 697
Daniels and Conyers, 169
Darier-Roussy sarcoid, 470
Davaine, 152
Davidson, 69
Davies-Colley operation for cleft palate, 787, *788*
Davis, 615
Davis' incision, 972
    for appendectomy, 1114
Dawbarn, 219
Dawbarn's sign in subdeltoid bursitis, 389
De Bonn, 1074
De Keating-Hart, 217
De Long's operation for prolapse of rectum, 1215
De Page, 1047
De Quervain, 920
De Vilbiss, 598
Death, apparent, resuscitation in, 500
  thymic, 490
Débridement of contused and lacerated wounds, 41
Decapsulation of kidney, 1242
Decerebrate rigidity, 690
Deciduoma malignum, 215
Decompression operation in brain tumors, 718
    in fracture of base of skull, 680
Decortication, pulmonary, 921
Decubitus, 30, *31*
  treatment, 33
  ulceration of cecal mucosa, 1074
Deer-fly fever, 156
Deformity, angel-wing, 1289
  gunstock, 288
  in fractures, 260
  Madelung's, of wrist, 1291
  silver-fork, 294
  Sprengel's, 1289
  Volkmann's congenital, of tibiotarsal joint, 1304
    supramalleolar, 1304
Degeneration, fatty, 21
  of nails, 473
  reaction of, 432
  wallerian, 431
Degenerative arthritis, 340
  inflammation, 21
Dehydration, postoperative treatment, 589
Delbet and Douay, 942
Delhi boil, 178
Delirium, **118**
  alcoholic, 120
  drug-habit, 120
  narcotic, 120
  of pneumonia, 120
  postoperative treatment, 589
  traumatic, 119
    direct, 120
    indirect, 120
  tremens, 120
    complicating fractures, 263
  typhoid, 120
Delorme's operation, 921
Deltoid ligament, rupture, in fracture of fibula, 324
Demigauntlet bandage, *523*
Denhardt's mouth-gag, *543*
Denman-Jones adjustable extension humerus splint, *287*
Dental caries, 807
  cysts, 814
  ulcer, 820
Dentigerous cysts, 205, **814**
    follicular, 814
    multilocular, 814
    radicular, 814
Dentition, congenital anomalies, 785
Depilation, radiation, 463
Depilatories, chemical, 463
Depilatory powder, 140
Depressed fractures, 255
Derbyshire neck, 476
Dermacentor denustus, 61

Dermacentor occidentalis, 61
Dermal leishmaniasis, 178
Dermatitis, blastomycetic, **176**, 468
  focus-tube, 74
  papilloma malignans, 209, **894**
  radium ray, **67**, 209
  Roentgen-ray, 67
Dermatogenic torticollis, 848
Dermatol, 139
Dermatolysis, 187
  of face, 798
Dermatoses, precancerous, **208**, 471
    Bowen's, 209
Dermoid cysts, 219
    branchial, 220
    lingual, 220
    of chest, 884
    of face, 801
    of mediastinum, 938
    of neck, 856
    of scalp, 668
    of skull, 671
    of tongue, 823
    ovarian, 220
    rectal, 220
    sacrococcygeal, 757
    sequestration, 220
    urachal, 220
  patches, 204
Desault's bandage, **525**, 526
  treatment of hemorrhage in chest wounds, 880
Desiccation, disinfection by, 132
  electric, 518
    in cancer, 217
Desjardins' point, 954
Desmarest and Sicard, 783
Desmoid tumor of abdominal wall, 971
    of muscle, 384
Desquamative inflammation, 21
Dextrin bandage, 531
Diabetes, arteriosclerosis in, 122
  hyperglycemia in, 122
  hypoglycemia in, 122, **123**
  in anesthesia, 539
  insulin in, **122**, 123, 124
  operations in, 122
    basal-metabolic diet before, 123
    preparation, 123
Diabetic acidosis, 124
  coma, 122
  endarteritis, 391
  gangrene, 101, **103**, 122
Diaphragm, laceration, 874
Diaphragmatic hernia, 1204
    congenital, 1204
    traumatic, 1204
Diarrhea, fatty, in pancreatic disease, 1150
  in carcinoma of colon, 1082
  in pancreatic disease, 1150
Diastasis, 346
  of abdominal wall, 960
  of recti muscles, 1201
  of rectum, interdigitation in, 971
Diathermy, general, therapeutic uses, 518
  in cancer, 217
  in inflammation, 23
  local, general uses, 518
Dichloramin-T, 134
  for wounds, 53
Dichlorethyl sulphid, effects of, 71
Didot's operation for syndactylism, 1292, *1293*
Diet after clean abdominal section, 588
  after operations not abdominal, 588
  after septic abdominal section, 589
  basal-metabolic, before operations in diabetes, 122
  before operations not involving abdominal cavity, 587
  in cholecystitis, 1143
  in peptic ulcer, 1008
  in postoperative constipation, 593
  postoperative, 592
  preoperative, 586
Dietl, 1227
Dietl's crisis, appendicitis and, differentiation, 1103
Differential-pressure apparatus, disadvantages, 878
    negative, 878
    positive, 878
Differential-pressure apparatus, Sauerbruch's, 878
  devices, 877
Digestive tract in anesthesia, 538
Digital compression in hemorrhage, 80
Digitus malleus, 1310
Dilatation of colon, gastric tetany in, 1031
    idiopathic, 1055
      congenital, 1055
  of duodenum, 1027
    acute, 1061
    chronic, 1061
      duodenojejunostomy for, 1061
  of stomach, acute, 1024
    chronic, 1025
    gastric tetany in, 1031
  of urethral stricture, 1269
Dilated veins, 194
Dimple, postanal, 758
Diphosgen, effects of, 71
Diphtheritic exudate, 20
  inflammation, 21
Diplegia, facial, 732
Diplococcus intracellularis meningitis, 688
Diploë, hemorrhage from, control, 705
Diptera, irritation of skin from, 59
Direct fractures, 257
Directors, fistula, *1210*
  grooved, 600
Disarticulation, 641, **648**
  at wrist, 651
  midphalangeal, 650
  of ankle-joint with removal of malleoli and articular surface of tibia, 656
  of hip-joint, 659
  of knee-joint, Smith's, 657
Disassociation of fibers of peripheral nerves, 338
Discrete polyps of stomach, 1034
Diseases produced by lower animals, 36
Disinfectants, 129
  biologic, 129
Disinfection, 128
  alcohol, 130
  chemical, 129
  cold, 131
  desiccation, 132
  electricity, 132
  heat, 129
  hot air, 129
    water, 130
  light, 132
  mechanical, 132
Dislocations, 346
  after-treatment, 350
  atypical, 346
  bilateral, 346
  complete, 346
  complicated, 346
  complications, 349
  compound, 346
  congenital, of knees, 374
    of patella, 374
      lateral, 374
  consecutive, 344
  double, 346
  habitual, 349
  incomplete, 346
  interphalangeal, 380
  Malgaigne's, 361
  methods of reduction, 350
  midtarsal, 380
  of ankle-joint, 377
  of articular processes of spine, 759
  of astragalus, 379
  of carpal bones, 362
      old, treatment, 364
    scaphoid, 362
  of carpus, **362**, 363
    forward, 362
  of cervical vetebra, 762
  of clavicle, 352
    acromial end, 353
    sternal end, 352
      backward, 352
      forward, 352
      upward, 352
  of elbow-joint, 358
    chronic, treatment, 360
    diverging, 361
    lateral, 360
Dislocations of elbow-joint, long-standing, treatment, 360
    medial, 360
  of extensor tendons of fingers, 1297
  of fibula, total, 377
    upper end, 377
  of foot, 377
    backward, *378*
    forward, 378
    lateral, 377
    medial, *377*
    upward, 379
  of greater multangular bone, 363
  of head of os capitatum, 363
  of hip, 366
    Albee's treatment, 369
    atypical, 367
    backward, 366
      Bigelow's treatment, 369
      Stimson's method of reducing, 368
      treatment, 368
    central, 367
    chronic, 370
    congenital, 372
      coxa vara and, differentiation, 373
      Lorenz's operation, 373
      open reduction, 373
      subtrochanteric osteotomy, 373
    dorsal, 367
    forward, 366
      Bigelow's treatment, 370
      treatment, 370
    iliopectineal, 367
    intracotyloid, 367
    ischiatic, 368
    obturator, 369
    pubic, 370
    sciatic, 368
    supracotyloid, 367
    tuberculosis and, differentiation, 372
    varieties, 366
  of humerus, 353
  of knee-joint, 376
    backward, 377
    forward, 376
    lateral, 377
    medial, 377
  of knees, congenital, 374
  of laryngeal cartilages, 837
  of larynx, 837
  of lower jaw, 351
  of lunate bone, anterior, 362
  of mandible, 351
  of medial meniscus of knee, 375
      Jones' operation, 375
  of metacarpal bones, 364
  of metacarpophalangeal joint, 364
  of navicular bone, 362
  of os magnum, 363
  of patella, 374
    edgewise, 374
    lateral, 374
    medial, 374
    vertical, 374
  of penis, 1278
  of phalanges, 366
  of radiocarpal articulation, 363
  of radius, 358, 361
    and ulna together, 358
    head, 361
  of scapula, 353
  of semilunar bone of wrist, 362
  of shoulder, 353
    associated with fracture of upper end of humerus, 357
    Bryant's sign, 354
    Callaway's sign, 354
    Cooper's treatment, 357
    Dugas' sign, 354
    erect, 354
    heel-in-axilla treatment, 357
    Kocher's treatment, 355
    long-standing, 357
    lower end, 353
    Malgaigne's treatment, 357
    prognosis, 357
    recurrent, 358
    Smith's treatment, 357
    Stimson's treatment, 355
    subclavicular, 354
    subcoracoid, 353

Dislocations of shoulder, subglenoid, 354
subspinous, 354
supracoracoid, 354
of shoulder-blade, 353
of spine, 760
atlas on epistropheus, 761
occiput on atlas, 761
of talus, 379
of tarsus, 380
of tendons, 386
of thumb, 364
backward, 364, 366
of tibia, 376
of toes, 380
of trapezium, 363
of ulna, 358, **361**
and radius together, 358
head, recurrent, 363
of wrist, 362, **363**
old, 346
unreduced, symptoms, 348
open, treatment, 351
optimum positions for ankylosis, 351
partial, 346
pathologic, 347
primitive, 346
recent, 346
recurrent, 349
special, 351
subastragaloid, 379
subclavicular, 354
subcoracoid, 354
subglenoid, 354
subtalar, 379
supracoracoid, 354
tarsal, transverse, 380
tarsometatarsal, 380
total, 346
treatment, 349
anesthesia, 349
Gunn's law, 350
prevention of complications, 351
typical, 346
with associated fracture, treatment, 350
Displacement of great toe, 1311
of little toe, 1311
Dissecting aneurysm, 391, **395**
porter's wart, 158, **467**
Dissection wound, 36
Dissectors, blunt, 597
Distoma hæmatobium, 62
hepaticum, 64
westermanii, 64
Districhiasis, 462
Divarication of recti, 1200
interdigitation in, 969
Diverticula, congenital, of esophagus, 861
intestinal, inflammation of, 1075
of bladder, 1250
congenital, 1250
of duodenum, 1028
of esophagus, 866
pressure, 866
pulsion, 866
traction, 866
of ileum, *1075*
of intestine, 1075
of stomach, 1028
with ulcer, *1028*
Diverticulitis, 1075
intestinal stricture in, 1066
Meckel's, 1055
Diverticulosis, duodenal, 1055
Diverticulum, Meckel's, 957, 1055
Division of peripheral nerves, 430
suture, 439
Divulsion of cardia, 1046
Dog nose, 176
Dolicocephalic skull, 669
Döllinger's treatment of tuberculous lymphadenitis, 855
Donn, 1164
Donovan's bodies, 169
Dor, 466
Dorrance, 269, 814
Dorsalis pedis artery, ligation of, 639
Dott-Fraser aseptic intestinal anastomosis, 1092
Douay and Delbet, 942
Double harelip, 786
knot, 606
Double lip, 789
navicular bone, 1291
penis, 1278
Doyen, 595, 873, 878, 1045
Doyen's fraise and burrs for perforating skull, *704*
gastric clamp, *1045*
stomach-forceps, *1012*
Dracunculus, 62
Draftsman's elbow, 390
Dragon pyelogram, 1225
Drain, cigarette-, 52
Mikulicz's, 52
in peritonitis, 983
peritoneal, dangers in use, 984
removal, 984
types, 983
tube, **51**, 592
Drainage, capillary, 51
gauze, 52
in peritonitis, 983
of renal pelvis, 1242
of wounds, 51
tubular, 51
Drains, 51
Dressing, dry, of wounds, 47
forceps, 600
moist, for wounds, 49
principle, *48*
solutions used, 50
postoperative, 592
powder, of wounds, 47
wet, for wounds, 49
principle, *49*
solutions used, 50
Drill, bone, 190, *273*, **383**
Drills, 599
Drop-finger, **301**, 1296
Drug addiction, trigeminal neuralgia and, differentiation, 727
Drug-habit coma, 118
delirium, 120
Drugs, injections into heart, 947
perlingual administration, 503
pernasal administration, 503
Drunkard's palsy, 450
Dry dressing of wounds, 47
gangrene, 101
Dubi, 166
Ducrey, 168
Duct colic, 1149
vitello-intestinal, anomalies of, 957
Ductless glands, 475
in anesthesia, 538
Ductus arteriosus, persistent, 943
Dudgeon and Ross, 979
Dugas' sign in dislocation of shoulder, 354
Dujarier, 1198
Dulness, Grocco's paravertebral triangle, in purulent pleurisy, 915
liver, obliterated, in pneumoperitoneum, 956
Dumb rabies, 154
Dumping stomach following gastroenterostomy, 1022
Duodenal diverticulosis, 1055
fistula, acute, 1005
obstruction, chronic, 1027
congenital, 1055
stasis, chronic, 1027
tube, uses, 503
ulcer, 1012, *1013*. See also *Ulcer, duodenal.*
Duodenojejunostomy for chronic duodenal dilatation, 1061
Duodenum, 998
dilatation, 1027
acute, 1061
chronic, 1061
duodenojejunostomy for, 1061
diverticula, 1028
obstruction, 1027
Dupré, 774
Dupuytren, 386, 816, 1291, 1295
Dupuytren's amputation of shoulder, 653
clamp, 1083
classification of burns, 66
contracture, 1295
fracture, **324**, 378
intestinal suture, 1086
splint, 531
Dura, hemorrhage from, control, 705
Durscon, 889
Dust-louse, 61
Duval-Barasty incision for exposure of heart, *949*
pericardiotomy, 949
Dwarfs, achondroplastic, 227
Dye-elimination test of liver function, 1120
Dyes as germicides, 137
Dysacusis, 734
Dyscrasic fracture, 257
Dysdiadokokinesia, 693
Dysenteric stenosis of intestine, 1069
stricture of intestine, 1066
Dyspepsia, 998
appendicular, 1105
in cholecystitis, 1136
in pancreatic disease, 1150
of hyperchlorhydria, 998
qualitative, 998
quantitative, 998
Dysphagia as symptom of disease of esophagus, 861
valsalviana, 850
Dyspituitarism, *491*, 492
Dyspnea, laryngeal, 926
Dysthyroidism, 478
Dystrophia adiposogenitalis, 492, **495**
Dysuria, 1224
in acute appendicitis, 1100

Ear, congenital malformations, 785
epithelioma, treatment, 804
Earle and Goodall, 946
Ecchymosis in fracture of base of skull, 678
Echinococcus cysts, 64
of abdominal wall, *955*
of bone, 239
of chest wall, 884
of face, 797
of liver, 1124, *1125*
hydrated thrill in, 1125
of lung, 935
of neck, 857
of skull, 684
tumors of spine and, differentiation, 779
Ecraseur, 596
Ectatic aneurysm, 396
Ectocyst, 1125
Ectopia testis, 1281
vesicæ, 1248
viscera, 957
Ectrodactylism, *1288*, 1289, **1293**
Ectromelus, 1288
Eczema of tongue, 822
Eczematous areas, chronic, in varicose veins, treatment, 418
Edebohls' nephropexy, 1228, **1242**
Edema, anthrax, 153
cerebral, 707
gangrenous, acute, 148
inflammatory, 21
malignant, bacillus of, 148
of skin, 461
of uvula, 830
pulmonary, 927
Edematous laryngitis, 838
Edmondson fracture extension tongs, *268*
Effleurage, 516
Effusion, pleural, 912
subphrenic abscess and, differentiation, 988
subpericranial, 666
Egebert, 1045
Egg-shell crackling in sarcoma of bone, 244
Egophony in hydrothorax, 912
in purulent pleurisy, 914
Eiche, 508
Eighth cranial nerve, lesions, 734
Einhorn, 533
Eiselsberg, 477
Eisendrath, 1146
Elastic bandage, 530
ligature, 596
Elbow, angler's, 381
draftsman's, 390
miner's, 390
Price's, 990, 1068
Elbow-joint, amputation, 651

Elbow-joint, arthrotomy, 343
dislocation, 358. See also *Dislocations of elbow-joint.*
fractures about, general treatment, 289
Jones' position, 289
Lundswathe, 289
optimum position for ankylosis, 264
pulled, 361
sprain, 362
subluxation, 361
Electric coagulation in cancer, 217
desiccation in cancer, 217
destruction of tissue, 518, 519
Electrical burns, 66, 73
tests to determine sensory conduction of peripheral nerves, 436
Electricity, disinfection by, 132
high-frequency currents, 518
therapeutic uses, 517
Electrocoagulation, 519
Electrodesiccation, 518
Electrolysis for hypertrichosis, 462
Elephant leg, 187
Elephantiasis, 187, 421
arabum, 187, 421
false, 422
filarial, 421
græcorum, 173
Kondoleon operation, 422
lupus, 424
neuromas, 459
of face, 798
of neck, 858
Sistrunk's operation, 422
skin in, 461
Elevation in arrest of hemorrhage, 83
Elevators, periosteal, 598
Eleventh cranial nerve, lesions, 736
Elimination of intestines, 1093
definition, 1088
methods, *1091*
Ellis' S-shaped line in purulent pleurisy, 915
Emaciation in pancreatic disease, 1150
Embolectomy, 98
pulmonary, 98
Embolic abscess, 27
aneurysm, 395
arteritis, 391
gangrene, 104
Embolism, air, complicating operations on thyroid, 488
cerebral, cerebral compression and, differentiation, 703
in operations on lung, 934
complicating fractures, 262
fat-, 97
from injection of paste into lung, 934
height of gangrene following, 94
Embolus, 97, 514
composition, 97
results, 97
seats, 97
varieties, 97
Embryoma of testes, 1286
Embryonic cysts, 219
Emergency operations in homes, 583
splint, 531
treatment of hemorrhage, 80
Emphysema, 833
hypertrophic, 930
in fracture of base of skull, 679
mediastinal, acute, 938
traumatic, 874
Empyema, 27, 914
abdominal, in pneumococcus peritonitis, 985
bacteria causing, 914
bilateral, 914
bismuth paste in, 917
Dakin's solution in, 916
drainage of pleural cavity in, *916*
egophony in, 915
Ellis' S-shaped line in, 915
encapsulated, 914
following influenza, 914
pneumonia, 914
great thickening of pleura and, differentiation, 915
Grocco's paravertebral triangle of dulness in, 915
loculated, 914
Empyema necessitatis, 915
neoplasm of lung and, differentiation, 915
persistent, due to foreign body, 917
pneumonia and, differentiation, 915
pulsating, 914
skodiac resonance in, 915
subphrenic abscess and, differentiation, 915
total, 914
treatment, 915
tuberculous, 935
ultra-acute, 914
Encephalocele, 670
Encephalography, 694
Encephaloid carcinoma, 207, 208
of breast, 899, 903
of stomach, 1037
Enchondroma, multiple, of phalanges, of hand, *243*
of chest, 885
of lung, 936
of neck, 858
Enchondroses, 189
Encysted hydrocele, inguinal hernia and, differentiation, 1184
Endarteritis, diabetic, 391
obliterative, 391, 393
tuberculous, 393
Endermic injections, 505
inoculation, 505
Endocyst, 1125
Endometrial adenoma of small intestine, 1079
implantation in small intestine, 1079
Endometritis, gonorrheal, treatment, 1267
Endothelioma, 202
of bone, 249
of brain, 717
of carotid gland, 859
of face, 801
of lung, 936
of peritoneum, 996
of pleura, 918
of spine, 775
treatment, 203
Endotherm knife in arrest of hemorrhage, 83
in cancer, 217
Endothermy in cancer, 216
monopolar, in cancer, 217
End-to-end arterial suture for aneurysm, 407, *408*
Enema, alum, 504
asafetida, 504
evacuant, 504
high, 505
in peritonitis, 985
low, 505
milk-and-molasses, 504
soap-suds, 504
stimulating, 504
triple, 504
Energy index for operability, 537
Engel's plaster-of-Paris saw, 530
English, 708
Enlargement. See *Hypertrophy.*
Enostosis, 189, 241
Enterectomy, 1094
definition, 1088
in stages, 1092
Enteric intussusception, 1062
Enteritis, gastric tetany in, 1031
Entero-anastomosis, 1090
definition, 1088
Enterocele, 1167, 1168, *1183*
Enterocolitis, chronic, in chronic appendicitis, 1106
Entero-entero-anastomosis, historical, 1045
Enteroliths, 1061
Enteroperitoneal tuberculosis of intestines, 1077
Enteropexy, definition, 1088
Enteroplasty, definition, 1088
Enterorrhaphy, definition, 1088
Enterostomy, definition, 1088
for jejunal toxemia in peritonitis, 984
high, for high intestinal obstruction, *1059*
Paul-Mixter tube for, *1093*
vaginal, *1064*, *1065*
Enterotomy, definition, 1088
Entero-uterine fistula, 1074
Enterovaginal fistula, 1074
Enterovesical fistula, 1074
Entozoa of chest wall, 884
Enucleation, amputation by, 647
Enuresis, 1247
Ephelides, 801
of chest, 884
Epiblastic odontoma, 205
Epicondyles of humerus, fracture, 288, 289
Epicritic sensation, 433
sense, 429
Epidermis, anatomy, 460
Epidermoid cancer, 210
Epididymectomy, 1284
Epididymis, encysted hydrocele, 1283
hydrocele, 1282
Epididymitis, gonorrheal, treatment, 1264
syphilitic, 1285
tuberculous, 1284
Epididymovasostomy, 1284
Epidural anesthesia, 575
Epifascial injection, 507
Epigastric hernia, 1202
Epiglottis, backward displacement, 833
burns and scalds, 70
fissure, 833
kinking, 833
Epilepsy, cerebral compression and, differentiation, 703
jacksonian, 708
traumatic, complicating skull injuries, 708
Epileptic coma, 118
Epileptiform neuralgia, 727
Epinephrin, 498
in physiologic saline to stimulate arrested heart, 947
intraventricular injection, 503
Epiphyseal separation, 257
Epiphysis, capital, of femur, separation, 309
lower, of femur, separation, 312, 316
of humerus, separation, 289
of radius, separation, 297
of tibia, separation, 322
upper, of femur, separation, 311
of humerus, separation of, 284
Epiphysitis, 239
metatarsal, 241
of head of second metatarsus, 240
of olecranon, 240
of os calcis, 240
of various epiphyses of ilium, 240
of tarsal scaphoid, 239
of tibial tubercle, 239
tuberculous, 237
vertebral, 240
Epiplocele, 1167, 1168
Epiplopexy for ascites, 995
Epispadias, 1248, 1278
Epistaxis, treatment, 89
Epithelial odontoma, 205, 814
pearls, 211
pneumonia, 935
tumors, 203
of face, 801
of umbilicus, 959
Epithelioma, 206, 210
adenoid, 214
basal-cell, 214
basal-squamous-cell, 214
columnar, 206
cylindrical, 215
hornifying squamous, 210
melanotic, 470
morphea-like, 472
of chest, 887
of ear, treatment, 804
of face, 802
of lip, *802*, *803*
of penis, 1280
of renal pelvis, 1242
of scrotum, 1287
of tongue, 823
of tonsils, 832
reticulated, 214
squamous, 206
of anus, 1218
of nipple, 804
ulcerating squamous, clinical characteristics, *211*

Epithelization, 25, 29
Eppinger and Hoff, 946
Epulis, alveolus, 812
  fibrous, 187
  method of removing, *813*
Erb-Duchenne syndrome, 447
Erb's sign in gastric tetany, 1032
Erection of penis, continuous, 1279
Ergot, gangrene from, 108
    treatment, 109
Erichsen, 707, 759
Erichsen's ligature, 85, 605
Erosion, gastric, 1006
Erysipelas, 144
  cellulocutaneous, 144
  facial, 144
  faucial, 144
  gangrenous, 145
  gastro-intestinal, 144
  neonatorum, 144
  of face, 793
  of scalp, 668
  phlegmonous, 144
  scrotal, 144
  treatment, 145
Erysipeloid, 146
Erythema, 66
  calorica, 73
  cancerous, *902*
  chemical, 67
  induratum, 30, 467, 470
  nodosum, 460
  of tongue, 822
Erythremia, 1161
Erythromelalgia, 106
Erythromelia, 106
Escherich, 146
Eshanelidze, 952
Esmarch, 645
Esmarch's chloroform bottle and inhaler, 547
  elastic rubber bandage, *81*
  tourniquet, 81
Esophageal bouginage, 869
Esophagectomy, radical, 871
Esophagismus, 865
Esophagitis, 865
  static, 868
Esophagobronchial fistula, 867
    congenital, 861
Esophagomalacia, 863, 864
Esophagoscope, Jackson's, *861*
Esophagoscopy, 861
Esophagospasm, 867
Esophagostomy, cervical, 871
Esophagotracheal fistula, congenital, 861
Esophagus, 860
  agenesis, 861
  auscultation, 860
  burns, 863
  cancer, 869
  clinical examination, 860
  congenital atresia, 861
    diverticula, 861
    malformations, 861
    stenosis, 861
  corrosion, 863
  diseases of, 860
    diagnosis, 860
    symptoms, 861
    treatment, 862
  diverticula, 866
    pressure, 866
    pulsion, 866
    traction, 866
  duplex, 861
  false passages, 863
  foreign bodies, 862
  hemorrhage, 864
  inflammation, 865
  inspection, 860
  palpation, 861
  paralysis, 866
  percussion, 861
  radiography, 860
  rupture, 863
  spasm, 865
  stenosis, 867
  stricture, 867
  surgical anatomy, 860
  traumatic injury, 862
  wounds, 862
Espundia, 179
Essential hematuria, 1223
Esser's method of skin-grafting, 617
Estlander's thoracoplasty, 922
Ethenyl-paradiethoxy-diphenylamidin hydrochlorid, local anesthesia by, 560
Ether anesthesia, 540. See also *Anesthesia, ether.*
  rausch, 544
Ethyl aminobenzoate, local anesthesia by, 560
  chlorid anesthesia, 552
Ethylene anesthesia, 551
    versus nitrous oxid anesthesia, 552
Eupad, 134
Eusol, 134
Evacuant enema, 504
  suppositories, 505
Evacuatio orbitæ, 800
Evacuation of colon in Hirschsprung's disease, 1057
Ewing, 181, 245, 249, 426, 427
Ewing's sarcoma, 249
    differential diagnosis, 254
    onion-layer appearance, 251, 254
    treatment, 251
Exanthematous necrosis of jaw, 810
Exarticulation, 641
Excision by dissection of varicose veins, 418
  of seminal vesicles, 1277
Excitement, postoperative treatment, 589
Excoriation, 38
Exemia, 112
Exenteratio cranii, 675
Exeresis, phrenic, 942
Exner, 783
Exomphalos, 957
Exophthalmic goiter, 476, 479
    circulatory symptoms, 480
    Dalrymple's sign, 480
    Joffroy's sign, 480
    metabolic rate, 481
    Möbius' sign, 480
    nervous symptoms, 481
    ocular symptoms, 480
    Stellwag's sign, 480
    thyroid crisis, 482
    von Graefe's sign, 480
Exostoses, 189, 241
  of orbit, 684
  of skull, 684
  subungual, 242, 474
Exsanguination-transfusion, 418
Exstrophy of bladder, 1248
Extensor paralysis of fingers, Stöffel's operation, 387
  of wrist, Jones' operation, 386
      Stiles' modification, 386
    Stöffel's operation, 387
  tendons, dislocation, 1297
    rupture, flexion of terminal phalanx from, 366
External gastric fistula, 1004
Extirpation of pancreatic cysts, 1155
Extracapsular fractures, 257
Extradural abscess, 687
  anesthesia, 575
  block, 575
Extravasation of blood, 78
  of urine in rupture of urethra, 1259
Extremities, 1288
  absence, 1288
  arterial thrombosis of, 97
  congenital defects, 1288
Extremity, lower, 1300
    bony defects, 1300
  upper, 1289
    acute lymphadenitis, 423
    congenital anomalies, 1289
Extroversion of bladder, 1248
Exudates, corpuscular, 20
  croupous, 20
  diphtheritic, 20
  fibrinous, 20
  hemorrhagic, 20
  inflammatory, 20
  serous, 20
Exudation, cellular, 20
  cysts, 220
    of breast, 895
  purulent, 20
Exudative inflammation, 21
Eyebrow, formation of, *612*
Eyelid, spasm, 731
Eyes, bandage for, *524*
  butyn anesthesia, 558
  cocain anesthesia, 557
  crossed bandage, 524
  fungating melanosarcoma, *200*

Face, 784
  actinomycosis, 797
  adenitis, 795
  adenoma, 802
  and jaws, actinomycosis, 812
  angioma, 799
  anthrax, 793
  atheromata, 801
  bird-, *619*, 805
  burns, 793
  carcinoma, 802
  chancre, 796
  chilblains, 793
  congenital malformations, 784
  cornu, 798
  cysticercus cysts, 798
  defect in, correction, after removal of rodent ulcer, *666*, *667*
  dermatolysis, 798
  dermoids, 801
  echinococcus cysts, 797
  elephantiasis, 798
  embryology, 784
  endothelioma, 801
  epithelial tumors, 801
  epithelioma, 802
  erysipelas, 793
  fibroma, 798
    molluscum, 798
  frost-bite, 793
  glanders, 794
  gumma tuberculosum, 795
  gunshot wounds, 791
  horns, 798
  infections, acute, 793
    chronic, 794
  keloid, 798
  leprosy, 797
  lifting, *733*, *791*
  lion, 229
  lipoma, 798
  lupus, 795
    non-ulcerative type, 795
    syphilis and, differentiation, 796
    ulcerative type, 795
    verrucose type, 795
  lymphangioma, 800
  moles, 799
  neurofibroma, 798
  nevus, 798
    angiectodes, 799
    araneus, 799
    flammeus, 800
    vasculosus, 799
    vinosus, 800
  osseous tuberculosis, 795
  rhagades, 796
  rodent ulcer, 802
  sarcoid infiltration, *795*
  sarcoma, 801
  sebaceous cysts, 801
  spider cancer, 799
  subcutaneous sarcoma, 801
    tubercle, 798
  syphilis, 796
    lupus and, differentiation, 796
  tetanus, 794
  traumatism, 790
  tuberculosis, 794
    cutis, 795
  tumors, 798
Facial angle of Camper, 670
  artery, ligation, 630
  clefts, 784, 785
  diplegia, 732
  erysipelas, 144
  muscles, spasm, 733
  nerve, anastomosis, 732
    lesions, 731
  neuralgia, 727
  paralysis, anastomosis operation for, 732, 733
    muscle transplantation for, 733
    peripheral, 731
    treatment, 732
  profile, 670

Facial spasm, 733
vein, thrombus, *412*
Facies hippocratica in peritonitis, 980
Fainting, 112
Fallen stomach, 1027
False aneurysm, 391, 394
arterial, treatment, 410
ankylosis, 342
elephantiasis, 422
incontinence of urine, 1248
knot, 606
neuroma, 187
pancreatic cyst, 1151
passages of esophagus, 863
pelvis, fractures, 301
Familial jaundice, acholuric, 1160
Fanz, 186
Farabeuf, 598
Farcin, 172
Farcy, 172
buds, 173
Farr's retractor, *487*
Fascia, properitoneal, 1194
transplantation, 619
Fasciola hepaticum, 64
Fat, transplantation, 618
Fat-embolism, 97
Fatty degeneration, 21
diarrhea in pancreatic disease, 1150
hernia, 192
osteomalacia, 335
Faucial erysipelas, 144
Fay, 744, 776
Fecal fistula, 1072
postoperative, in appendicitis, 1117
impaction, 1207
vomiting in strangulated hernia, 1174
Feces, incontinence of, 1207
Feet. See *Foot*.
Fehleisen, 144
Fell and O'Dwyer, 878
Felon, 1297
bone, subperiosteal, 1298
subcutaneous, 1297
subcuticular, 1297
synovial thecal, 1298
Femoral artery, ligation, 637
thrombosis of, gangrene from, *96*
canal, *1165*
cysts of, femoral hernia and, differentiation, 1197
cutaneous nerve, lateral, injuries, 457
hernia, 1166, *1171*, *1172*, *1173*, *1174*, **1193**. See also *Hernia, femoral*.
nerve, injuries, 456
Femur, capital epiphysis, separation, 309
condyle, separation, 312
epiphysis, lower, separation of, 312, 316
upper separation of, 311
fracture, neck, 304. See also *Fracture of femur, neck*.
osteogenic sarcoma, 246
osteosarcoma, *246*, *248*
Fenwick, 733
Ferguson, 17, 598
Ferguson's forceps, 600
incision for tumors of upper jaw, 817
modification of Pirogoff's amputation of ankle, 656
operation for cleft-palate, 787, *788*
for inguinal hernia, 1191
Fetal adenoma, 476
of thyroid gland, 483
osteogenesis imperfecta, 225
Fever, 23
catheter, 1271
therapy, 513
urinary, 1271
Fibers, motor, transplantation of, 783
Fibrillar neuroma, 190
Fibrillation, auricular, complicating operations on thyroid, 489
Fibrin, purulent, in peritoneum, 976
Fibrinous exudate, 20
Fibro-adenoma of breast, 897
intracanalicular, 897
Fibroblastoma, arachnoid, 775
Fibroblasts, 25
Fibrocellular tumor, 187
Fibrocystic disease of jaw, 814
Fibroid phthisis, 935
recurrent, of Paget, 200, 384
Fibroid tuberculosis, 159
tumors of abdominal wall, 971
Fibrolipoma, 193
Fibroma, 186
comparative pathology, 187
diffuse, 193
hard, 186
intracanalicular, 187
molluscum, *186*, 187, 469
of face, 798
of neck, 858
of abdominal wall, 971
of bladder, 1257
of bone, 243
of brain, 717
of bursæ, 390
of chest, 884
of face, 798
of lung, 936
of neck, 858
of parotid, 829
of testis, 1285
of upper jaw, 816
papillomatous, 187
pericanalicular, 187
periductal, of breast, 896
soft, 186
treatment, 187
Fibromatosis, diffuse, of neck, 858
Fibromyoma, 191
of breast, 897
Fibroneuroma of chest, 884
Fibroplastic tumor, 200
Fibrosarcoma, 200
of muscle, 384
of umbilicus, 959
parosteal, 245
periosseous, 245
Fibrosis, 21
Fibrositis, 382
brachial, 382
gluteal, 382
intercostal, 382
lumbosacral, 382
Fibrous ankylosis, 342
cavernositis, 1280
epulis, 187
odontoma, 205
polyps, 187
tuberculous peritonitis, 991, 992
Fibula, absence, 1300
and tibia together, fracture, 321
dislocation, total, 377
upper end, 377
fracture, 323
neck, 323
osteogenic sarcoma, 246
Field tourniquet, 81
Fifth cranial nerve lesions, 726
Figure-of-8 bandage, 522
descending, 522
in fracture of clavicle, 280
Filaria, 62
bancrofti, 62
demarquayi, 62
diurna, 62
in bladder, 1256
loa, 62
medinensis, 62
nocturna, 62
perstans, 62
sanguinis, 62
Filarial elephantiasis, 421
lymphangiectasis, 421
Filariasis, 62, 421
Fingers, absence, 1288, *1289*, **1293**
absence of, compound abdominal flap as substitute for, 620
transplantation of toe as substitute for, 620
amputation, 650
through distal phalanx, 650
middle phalanx, 650
proximal phalanx, 650
baseball-, 301, 1296
chancre, 1299
clubbing, 229
congenital contracture, 1293
drop-, 301, 1296
exchange method, 620
extensor paralysis, Stöffel's operation, 387
tendons, dislocation, 1297
hippocratic, 229
Fingers, hypertrophy, 1289, **1292**
mallet-, 301, 1296
partial giantism, 1292
snap-, 1296
spring-, 1296
supernumerary, 1289
syphilis, 1299
test in fracture of neck of femur, 306
traumatic amputation, *43*
trigger-, 1296
web-, 1289, **1292**
Finney, 1019, 1045, 1046, 1052
Finney's pyloroplasty, *1022*, *1023*, *1024*
Finochetti stirrup, 269
Finsterer-Hoffmeister method of partial gastrectomy, *1039*
Fischira, 219
Fish, injuries produced by, 56
Fish-hook stomach, *999*, *1025*
Fissura thoracis lateralis transversa, 873
parasternalis, 873
Fissural angioma, 194
Fissure, congenital, of larynx and trachea, 832
in ano, 1211
Boyer's operation, 1212
sentinel pile in, 1211
submucous, 1212
of chest, 873
of epiglottis, 833
of sternum, 872
Fissured fractures, 255
Fist-percussion, Murphy's, of kidney 1223
Fistula, **34**
anorectal, 1209
biliary, 958
external, 1145
operations for, 1146
branchial, 845
bronchial, 934
bronchocutaneous, 934
bronchopleural, 934
congenital, of larynx and trachea, 832
director, angular, *1210*
Martin's, *1210*
duodenal, acute, 1005
entero-uterine, 1074
enterovaginal, 1074
enterovesical, 1074
esophagobronchial, 867
congenital, 861
esophagotracheal, congenital, 861
fecal, 1072
postoperative, in appendicitis, 1117
gastric, 1004
acute, 1005
external, 1005
diagnosis, 1005
internal, 1004
diagnosis, 1005
horseshoe, 1209
in ano, 1209
internal, 34
intestinal, 958
carcinoma with, 1073
external, 1072
internal, 1073
jejunal, 1074
knife, Martin's, *1211*
labial, 784
of lymph-glands, 419
of neck, 845
penile, complicating urethral stricture, 1271
pilonidal, 468
preauricular, 790
rectal, complicating urethral stricture, 1271
sacrococcygeal, congenital, 758
salivary, 827, 828
thyroglossal, 845
treatment, 35
umbilical, 958
gastric, 958
urinary, 958
complicating urethral stricture, 1271
varieties, 34
vitello-intestinal, 958
Fistulectomy, abdominal, *1073*
Fitz, 1151
Fixed bandage, 530
Flajani's disease, 479

Flannel traction-strips in fractures, 267
Flap amputation, 646
of leg, *647*
operation for cleft-palate, 787, *788*
Flaps, skin, 610
compound, 610
direct transference, 610
double-faced, 610
indirect transference, 610
island, 610
lined, 610
rotation of, Indian method, 613
sliding of French method, 612
transfer of, from distant part, 613
Italian method, 613
tagliacotian method, 613
with vascular pedicle only, 613
tube grafts, 611
Flat chest, 873
Flat-cell cancer, 210
Flat-foot, 1304
acute painful, 1306
adolescent, 1306
paralytic, 1307
rigid, 1306
spasmodic, 1307
static, 1306
Flatulence, 1032
Flea, bites of, diseases produced by, 59
jigger, 60
red, 60
Fleshy warts, 801
Flexion of terminal phalanx from rupture of extensor tendon, 366
Flies, irritation of skin from, 59
Floating kidney, 1227
patella, 331
spleen, 1158
Flour-paste bandage, 531
Fluhrer, 599
Flukes, 62
Flutter, mediastinal, 877
Focus-tube dermatitis, 74
Follicular cystoma, proliferating, 814
dental cysts, 814
infection of axilla, 144
odontoma, 205, 814
compound, 205
Folliculitis, gonorrheal, treatment, 1263
Food-ball in stomach, 1003
Food-ease, 998
in duodenal ulcer, 1013
in gastric ulcer, 1007
Foot, amputation, 653. See also *Amputation of foot.*
club-, 1307. See also *Talipes.*
congenital hypertrophy, 1300
defects, 1300
dislocation, 377
backward, *378*
forward, 378
lateral, 377
upward, 379
flat-, 1304. See also *Flat-foot.*
Madura, 175
osteogenic sarcoma, 246
phantom, 644
splay-, 1304
supernumerary, of foot, 1304
trench-, 109
Forbe's modification of Chopart's amputation of foot, 655
Forceps, arterial, 600
Babcock's viscera, *1067*
bone-cutting, 598
bone-holding, 598
Collin's tongue-holding, *540*
crushing, Payr's, 1050
Doyen's stomach, *1012*
dressing, 600
Ferguson's, 600
for application and removal of Michel clips, *605*
Halsted's, 600, *601*
Jackson's, *925*, *926*
Kelly-Péan, 600
Kelly's hemostatic, 600, *601*
Kocher's, 600
hemostatic, *84*
Lenhartz's stomach-clamp for gastroenterostomy, *1012*
Liston's bone-cutting, *597*
Ochsner's, 600
O'Hara's 1092
Forceps, plaster spreading, *530*
Rankin's, 1092
sequestrum, 598
splinter, 601
tenaculum, 599
thumb, for appendectomy, *1108*
tissue, 600
viscera, for appendectomy, *1108*
volsellum, *599*, 600
Forcipressure, 600
in arrest of hemorrhage, 84
Forearm, cellulitis, 1299
fracture, optimum position for retention, 265
Foregut, 1053
Foreign bodies in air-passages, 833
in bladder, 1251
in bronchus, 924
abscess from, 928
in esophagus, 862
in intestines, 1061
Vienna treatment, 1062
in palm, 1297
in peritoneum, 977
in pleura, 917
in spine, removal, 780
in stomach, 1003
from adjacent structure, 1003
Vienna treatment, 1004
in submaxillary duct, 826
in tongue, 820
in urethra, 1259
Forestier, 509
Forestier and Sicard, 923
Forlanini, 940
Formaldehyd as disinfectant, 136
sterilizers, 136
Formalin, 136
glycerin, 136
Formic aldehyd as disinfectant, 136
Formol, 136
Forneau, 533
Forster's method of rhizotomy, 781
Fossa ovalis, anatomy, 1194
Fouli's tourniquet, 82
Fournier's tooth, 163, *164*
Four-tailed bandage of head, 527
Fourth cranial nerve, lesions, 726
venereal disease, 157
Fowler's operation, 921
Fracture-dislocation of spine, 764
Fractures, 255
abnormal mobility in, 260
about elbow, general treatment, 289
Jones' position, 289
Lund swathe, 289
agenetic, 257
anatomical result, 262
apophyseal, 255
articular, 257
atrophic, 257
auscultation in, 261
avulsion, 257
bands for, 271
Barton's, 296
Battle's sign in, 261
bending, 257
Bennett's, 299
bone regeneration, 260
bone-inlays for, 271
box, *322*
bursting, 257
by osteoclast, 1303
callus formation, 259
cart-wheel, 317
chauffeur's, 295
classification, according to absence or existence of exterior communication, 257
to application of force, 257
to degree, 255
to line of fracture, 256
to location, 257
closed, 257
Colles', 294
Cotton-Lodor treatment, 295
comminuted, 256
complete, 255
complicated, 256
complications, 262
compound, 257
delayed primary closure, 272
infected, operation in, 54
primary closure, 271
Fractures, compound, treatment, 271
compression, **256**, 257
of vertebral bodies, 764
congenital, 258
of femur, 315
crepitus in, 260
crushing, 256
of vertebral bodies, 764
deformity in, 260
delayed union, 273
depressed, 255
diagnosis, 261
differential diagnosis, 262
direct, 257
dislocation of ankle, 323
treatment, 325
Dupuytren's, 324, 378
dyscrasic, 257
etiology, 258
extracapsular, 257
fissured, 255
flannel traction-strips in, 267
functional result, 262
glue adhesion in, 267
greenstick, 255
of clavicle, 280
gunshot, of skull, 674
gutter, 255
hemorrhagic blebs in, 261
ice-tongs used in, 269
impacted, 256
incomplete, 255
indirect, 257
inflammatory, 258
intra-articular, 257
intracapsular, 257
intramedullary bone-peg in, *273*
intra-uterine, 258
leukocytosis in, 261
linear, 255
location, 258
longitudinal, 256
loss of function in, 260
Malgaigne's, 301
nailing, 270
neoplastic, 258
neurogenic, 257
non-union, 273
oblique, 256
of acetabulum, 303
floor, 303
posterior and upper lip, 303
of acromion, 281
of ankle, optimum position for ankylosis, 265
of astragalus, 327
of atlas, 761
of calcaneus, 326
compression, 326
impaction, 326
sustentaculum tali, 326
tuberosity, 326
of capitate, 299
of carpal bones, 298
of clavicle, 279
acromial end, 280
between conoid and trapezoid ligaments, 280
greenstick, 280
middle, 280
sternal end, 279
of coccyx, 304
of collar-bone, 279
of coracoid process, 281
of coronoid process of ulna, 291
of costal cartilage, 278
of elbow-joint, optimum position for ankylosis, 264
of femur, congenital, 315
extracapsular, 309
in children, 315
intertrochanteric, 308
lower end, supracondylar, 316
T-shaped, 316
neck, 304
base, *304*, 309
bitrochanteric test, 310
Bryant's triangle, 306
Chiene's test, 306
clinical tests, 306
finger test, 306
in children and infants, 308
large part, 309
Ludloff's sign, 306

Fractures of femur, neck, Nélaton's line, 306
subcapital or intracapsular, *304*
ununited, 308
Albee's operation, 308
bone-graft in, 308
Bracket's operation, 308
Lorenz operation, 308
Whitman's operation, 308
pertrochanteric, 309
shaft, 311
deformity, 311
lower end, 312
treatment, 314
middle third, treatment, 314
T-shaped, 312
transverse, 312
treatment, 312
duration of, 315
upper third, treatment, 313
supracondylar, treatment, 314
of fibula, 323
and tibia together, 321
deformity, 324
neck, *323*
rupture of internal lateral ligament in, 324
of interosseous ligament in, 324
of forearm, optimum position for retention, 265
of hip-joint, optimum position for ankylosis, 265
of humerus, 282
anatomic neck, 282
epicondyles, 288, **289**
external condyle, 289
extracapsular, 283
greater tubercle, 285
head, 285
intercondyloid, 288
internal condyle, 288
intracapsular, 282
lesser tubercle, 285
lower end, 287
third, extension, *286*
flexion, *286*
shaft, 285
treatment, 287
surgical neck, 283
impacted, *283*
T-, 288
transverse supracondyloid, 288
upper end, 282
third, spiral comminuted, *286*
Y-, 288
of hyoid bone, 850
of ischium, 303
of jaw, 275, **276**
of knee-cap, 317
of knee-joint, optimum position for ankylosis, 265
of lacrimal bone, 275
of larynx, 836
of lesser trochanter, 311
of lunate, 299
of malar bone, 275
of mandible, 276
of maxilla, 275, **276**
of metacarpal bone, first, base of, 299
shafts, 300
of metatarsals, 327
base of fifth, 328
of nasal bones, 274
of navicular bone, 298
of olecranon process, 290
of os calcis, 326
of os magnum, 299
of patella, 317
prognosis, 319
transverse, 317
of pelvis, 301
treatment, 303
of penis, 1278
of phalanges, **300**, 327
proximal, 300
of radius, 292
and ulna, both, 297
head, 292
lower end, *293*, 294
with backward displacement, 294
with forward displacement, 295
neck, 292
Fractures of radius, posterior articular margin, 296
shaft, 293
above insertion of pronator teres, 293
below insertion of pronator teres, 294
comminuted, *292*
upper third, *291*
of ribs, 277
of sacrum, 303
of scaphoid bone, 298
of scapula, 281
anatomic neck, 282
body, 281
surgical neck, 281
of semilunar bone, 299
of sesamoid of great toe, 328
of shoulder-blade, 281
of shoulder-joint, optimum position for ankylosis, 264
of skull, anterior fossa, 679
base, 677
Battle's sign, 678
cerebral nerve lesions in, 679
cranial nerve lesions in, 679
decompression in, 680
ecchymosis in, 678
emphysema in, 679
escape of cerebrospinal fluid in, 679
hemorrhage in, 679
ring, 677
swelling in, 677
bending, 671
bursting, 672, *673*
by contrecoup, 673
congenital, 665
grooved, 671
gunshot, 674
gutter, 671
indentation, 671
linear, 671, *672*
middle fossa, 679
posterior fossa, 680
punctured, 673
vertex, 671–676
of spinal lamina, 763
of spinous processes, 763
of sternum, 278
of talus, 327
of tarsus, 327
of terminal phalanx of thumb, comminuted, 301
of tibia, 319
and fibula together, 321
malleolus, 322
shaft, 321
tuberosity, 320
upper end, 319
of trachea, 836
of transverse process of spine, 763
of ulna, 290
and radius, both, 297
coronoid process, 291
olecranon process, 290
shaft, 291
styloid process, 292
of wrist, 298
of wrist-joint optimum position for ankylosis, 265
of zygoma, 275
open, 257
operative treatment, 269
ossification in, 260
pain in, 261
pathologic, 257
changes predisposing to, 258
percussion in, 261
periarticular, 257
plating, **270**, 271
pond, 255, **671**
Pott's, 324
prognosis, 262
repair, 259
resin plaster in, 266
ring, of base of skull, 677
roentgen examination, 262
secondary deformity, 262
senile, 257
simple, 257
skeletal traction in, 238
skin traction in, 268
Smith's, 295
Fractures, special, 274
spiral, 256
splinter, 255
spontaneous, 257
stellate, 255
subperiosteal, 257
suggillation in, 261
swelling in, 261
symptoms, 260
T-, of humerus, 288
table, Hawley's, *265*
torsion, **256**, 257
transverse, 256
treatment, 263
internal fixation, *269*
operative, 269
optimum position for ankylosis, 264
for retention, 264
position, 264
prevention of further injury, 263
reduction, 264
retention of fixation, 265
setting the broken bone, 264
traction, 266
ununited, 273
varieties, 255
wiring, 270
Y-, of humerus, 288
zinc-oxid adhesive plaster in, 266
Fragilitas ossium, 224
predisposing to fractures, 258
Framboesia tropica, **166**
Franck, 946
Frank, 1045
Frank's gastrostomy, 1047
Franke, 783
Fränkel-Babcock telescopic anastomosis, *1043*, *1048*
Fraser, 56, 58
Fraser-Dott aseptic intestinal anastomosis, 1092
Frazier, 736, 783, 852
Frazier and Spiller, 729, 733
Frazier's chordotomy knives, *782*
retractor, *730*, 779
trocar, *711*
Freckles, 801
Freeman, 271
Freiberg, 241
Freiberg's infraction of metatarsal head, 328
Freiberg-Köhler disease, 241
French method of sliding skin flaps, 612
Frenum of tongue, excessive length of, 820
Freund, 873, 939, 942
Freund's disease, 930
operation, 942
Frick, 960
Friction fremitus in abdomen, 956
knot, 606
Friedel's operation for varicose veins, 417
Friedrich, 920
Friedrich and Brauer, 940
pneumolysis, 941
Frisch, 176
Fröhlich's syndrome, 492, **495**
Froin's syndrome, 746
Froment's sign of ulnar nerve paralysis, 455
Frost-bite, 72
of face, 793
Fulguration in cancer, 217
Fuller, 1154
Fungating melanosarcoma of eye, *200*
Fungi hematoides, 188
Fungoid neoplasm, inflammatory, 175
Fungus, cerebral, 724
hæmatodes, 210
hematoma, 469
testis, *1285*
umbilical, 959
Fungus-foot of India, 175
Funicular hernia, 1178
hydrocele, 1282
Funnel-breast, 872
Funnel-chest, 872
Furbringer's method of sterilization of hands, 581
Furious rabies, 154
Furuncle, 141, **464**

Furuncle of scalp, 668
treatment, 142
Furunculosis, 464
Fusiform aneurysm, 398
Futaki, 168

Gadfly boils, 59
Gaedeke, 533
Gait, steppage, 458
Galactocele, 220, **896**
Galen's bandage, 528
Gall-bladder, 1134
amebiasis, 1136
ascending biliary infection, 1135
bile-infection, 1135
carcinoma, *1148*, 1149
colic, 1137
congenital anomalies, 1134
disease, stages of, 1136
gall-stones in, *1119*, 1133
giardia infection, 1136
hematogenous infection, 1135
hydrops, 1131, *1132*, *1133*, *1136*
incisions, 974
inflammation, 1134. See also *Cholecystitis*.
lymphatic infection, 1136
operation on, structures subject to injury in, *1146*
propinquity infection, 1136
rupture, 1134
strawberry, 1135
structure subject to injury in operation, *1146*
traumatic injury, 1134
white bile in, 1131
Galloping consumption, 935
Gall-stones, 1130, *1131*, *1136*
bilirubin-calcium, 1131
calcium carbonate, 1131
Charcot's intermittent fever in, 1133
cholecystic infection as cause, 1132
cholesterin, 1130
composition, 1130
hypercholesteremia as cause, 1133
in common duct, 1133
in gall-bladder, *1119*, 1133
in intestines, 1061, *1062*
in pregnancy, 1132
in stomach, 1003
peptic ulcer and, differentiation, 1017
point of obstruction, 1131
scoop, *1143*
stagnation of bile as cause, 1133
Galt's trephine, *599*
Gamma-diethylamino-propyl-cinnamate hydrochlorid, local anesthesia by, 559
Ganglion, 385
compound, 385
gasserian, resection, in trigeminal neuralgia, 729
of popliteal space, 390
submaxillary, destruction of, 851
Ganglionar neuroma, 190
Gangosa, 180
Gangrene, 22, 100, **101**
arteriosclerotic, 102
bacterial, 109
carbolic, *108*, 109
chemical, 109
diabetic, 101, **103**, 124
direct, 101
dry, 101
from gunshot wound of pelvis, *85*
embolic, 104
foudroyant, 148
from ergot, 108
from strangulation, 105
from thrombo-angiitis obliterans, *392*, *393*
from thrombosis of femoral artery, *96*
gas, **109**, 148
treatment, 110
height of, following embolism, 94
following thrombosis, 94
hospital, 109
impending capillary circulation test for, 94
hyperemia test for, 94
Matas' test for, 94
Moskowitz's test for, 94
Sandrock's test for, 94
Gangrene, indirect, 101
juvenile, 105
line of demarcation, 101
of separation, 101
microbic, 101
mixed, 101
moist, 101
of penis, 1280
of aged, 102
of appendix, *1097*
from stricture, *1099*
of lung, 929
phagedenic, 109
presenile, 105
spontaneous, 105
primary mephitic, 148
senile, 101, **102**
symmetrical, 107
white, 104
Gangrenous appendicitis, *1099*, 1101
balanitis, 157
edema, acute, 148
erysipelas, 145
infection, 125
progressive, of skin, 466
inflammation, 21
stomatitis, **110**, 820
Gaps in peripheral nerves, 440. See also *Peripheral nerves, gaps in*.
Gardener's spade deformity, 295
Garre, 236
Garrote tourniquet, 81
Gas, chlorin, effects of, **71**, 72
gangrene, **109**, 148
treatment, 110
infection, 125
lacrimatory, effects of, 71
mustard, effects of, 71
suffocating, effect of, 71
tear-, effects of, 71
Gas-bacillus infection, 148
of muscle, 382
treatment, 149
Gas-cysts, 1076
Gases, intestinal, 1053
Gasky, 148
Gas-pain in anesthesia, 536
Gasserian ganglion, injection, in trigeminal neuralgia, 729
resection, in trigeminal neuralgia, 729
Gastralgia, 1033
Gastrectasis, **1023**, 1025
gastroplication for, *1051*
Gastrectomy, Kocher's clamp for, *1050*
partial, **1043**, 1052
Billroth, modifications, *1043*, *1048*
Billroth I, *1038*, 1052
modification of, *1048*, *1050*
Billroth II, *1038*, 1052
Fränkel-Babcock anastomosis in, *1043*, *1048*
historical, 1045
Hoffmeister-Finsterer method, *1039*
Kocher's method, *1038*, *1050*
Kronlein method, 1039
lines for division of stomach, *1041*
lymphatic drainage of stomach in relation to, *1042*
Mikulicz's method, 1038
older methods, *1038*
points of ligation of arteries, *1040*
recent methods, 1039
Reichel-Polya method, *1030*, *1039*, 1052
Balfour's modification, *1039*
technic, 1052
total, 1052
historical, 1045
Gastric abscess, 1004
anacidity, preoperative treatment, 586
anastomosis, mechanical aids in, 1090
crises, treatment, 783
erosion, 1006
fistula, 1004
acute, 1005
internal, 1004
polyps, 1034, *1035*
discrete, 1034
tetany, 1031
accoucheur's hand in, 1031
Chvostek's sign, 1032
Gastric tetany, Erb's sign, 1032
Hoffman's sign, 1032
Trousseau's sign, 1032
ulcer, *1005* See also *Ulcer, gastric*.
umbilical fistula, 958
Gastritis, phlegmonous, 1004
suppurative, 1004
Gastrodiaphany, 956
Gastroduodenitis, phlegmonous, 1004
Gastroduodenostomy, historical, 1045
Gastro-enterostomy, *1016*, *1017*, *1018*, *1019*, *1020*
anterior, *1026*, 1049
complications, treatment, 1021
contraction of new orifice following, 1022
dumping stomach following, 1022
en Y, Roux', *1044*, 1045
for gastric ulcer, historical, 1045
hemorrhage into stomach and bowel following, 1022
historical, 1045
intestinal obstruction following, 1023
intussusception following, 1023
jejunal obstruction following, 1021
leakage following, 1022
Lenhartz's stomach-clamp forceps for, *1012*
posterior, *1015*, *1021*, 1051
pulmonary complications following, 1023
ulcer, 1019
vicious circle following, 1021
von Hacker's, 1051
Wölfler's, 1049
Gastro-intestinal complications in anesthesia, 535
erysipelas, 144
toxemia, gastric tetany in, 1031
tract, effect of spinal anesthesia upon, 564
operations on, preoperative treatment, 586
Gastrolysis, 1048
Gastromesenteric ileus, acute, 1061
Gastropexy, 1048
Gastroplication, 1048
for gastrectasia, *1051*
Gastroptosis, 1027
Beyea's operation, 1027
Gastrorrhagia, 1023
Gastrorrhaphy, 1048
Gastroscope, Jackson's, *861*
Gastroscopy, 999
Gastrostomy, 1047
Frank's, 1047
historical, 1045
Kader's, *1046*, 1047
Stamm's, 1047
Ssabanajew-Frank, 1047
Witzel's, 1047
Gastrostomy-pyloroscopy, 999
Gastrosuccorrhea, 1033
Gastrotomy, 1046
Gastroxynsis, Rossbach's, 1033
Gaucher's disease, 1163
Gauntlet bandage, *522*
Gauze drainage, 52
iodoform, 138
Gelatinoid cancer of breast, 899, **904**
Gely's intestinal suture, 1088
Genevrier's solution, 416
Genitofemoral nerve, 953
Genito-urinary organs, 1222
functional disorders, 1246
roentgen study, 1225
schistosomiasis, 63
Gentian-violet, 138
in blood-disinfection, 127
Genu valgum, 1302
rachiticum, 1302
staticum, 1302
varum, 1303
Geographic tongue, 822
Germicides, 128
Giant bedbug, bite of, 60
growth, congenital, 427
Giant-cell, 26
sarcoma, 252
tumor, 187
benign, of bone, 252
differential diagnosis, 254
of bursæ, 390
of skull, 685

Giant-cell tumor, treatment, 188
Giardia infection of gall-bladder, 1136
Giardiasis, 1074
Gibbosity, 767
Gibbus, 767
Gibson's bandage, 523
Gies' joints, 339
Gigantism, *491*, **494**
  partial, of fingers, 1292
Gigli's wire saw, 599, *705*
Gilchrist, 176, 856
Gill, 260
Gillies, 611
Gimbernat, 1195
Gingivitis, 818
Gland-cell carcinoma, 210
Glanders, 172
  of face, 794
Glandular urethritis, chronic, 1265
Glans penis, inflammation, 1279
Glass arm, 381
Gleet, 1251
Glénard's disease, 1158
Glioma, 191
  of brain, **713**, 717
Gliosis, 191
Glossitis, marginate, 821
Glossopharyngeal nerve, lesions, 735
    neuralgia, 735
Glossy skin, 432
Glottis, burns and scalds, 70
Glove anesthesia, 433
Gluck, 598
Glucose deficiency in jaundice, 1128
Glue adhesion in fractures, 267
  Heusner's, 267
  Sinclair's, 267
Glue-and-oxid-of-zinc bandage, 531
Gluteal artery, inferior, ligation of, 636
    superior, ligation of, 636
  fibrositis, 382
  nerve, superior, injuries, 456
  stabilization for extreme relaxation of hip, 1302
Glutol, 136
Glycerin suppositories, 505
Glycosuria complicating skull injuries, 708
  in pancreatic disease, 1150
Glycothymol, 137
Gnathoschisis, 785
Goetsch, 479
Goiter, 476
  adenomatous, 476
  colloid, 476
  exophthalmic, 476, **479**. See also *Exophthalmic goiter.*
  intrathoracic, 475
  malignant, 476
  parenchymatous, 476
    simple, 479
  retrosternal, 475
  simple, 476
Gold-blindness, 73
Goldheizer and Peck, 169
Golfer's back, 381
Golf-hole ureteral orifice, 1256
Gonococcus, 147
  infection, 147
  peritonitis, 976
  vaccine, 148
Gonorrhea, 1260
  acute prostatitis complicating, treatment, 1264
  treatment, 1262
    abortive, 1262
    prophylactic, 1262
  anterior, 1261
    subacute, treatment, 1263
  beer-test, 1260
  chronic, 1264
    glandular, 1265
    granular patches, 1264
    posterior, 1265
    prostatitis complicating, 1265
    seminal vesiculitis complicating, 1265
  cure, 1266
  epididymitis complicating, treatment, 1264
  folliculitis complicating, treatment, 1263
  in women, 1266
Gonorrhea in women, urethritis complicating, treatment, 1266
  posterior, 1261
    acute, treatment, 1263
  prostatic abscess complicating, treatment, 1264
  seminal vesiculitis complicating, treatment, 1264
  subacute stage, treatment, 1263
Gonorrheal arthritis, 148, **334**
  bartholinitis, treatment, 1266
  cystitis, 1255
  endometritis, treatment, 1267
  metritis, treatment, 1267
  ophthalmia, Crede's method of preventing, 136, **148**
  peritonitis, 148
  salpingitis, treatment, 1267
  urethritis, 1260. See also *Gonorrhea.*
  vaginitis, treatment, 1266
  vulvovaginitis, 1267
Gooch's splint, 531
Goodall and Earle, 946
Gorget, Teale's, *1269*
Gouge, bone, *235*
Gould's intestinal suture, 1087
Gouley's sound, *1268*
Goundou, 176
Gouty ulcer, 31
Gowers, 382
Gown, sterile, 582
Gradenigo's syndrome in brain abscess 709
  in meningitis, 688
Graefe's sign in exophthalmic goiter, 480
Graft, cable, 443
Grafting, nerve-, for gaps in peripheral nerves, 443
  skin-, 614. See also *Skin-grafting.*
Graham, 933
Graham-Cole cholecystography, 1119
Granny knot, 606
Grant, 1055
Grant's method of tying knot with forceps, *622*, *623*
Granulation tissue, 25
Granulations, 25
Granuloma, 158
  coccidioidal, 239
  fungoides, **175**
  inguinale, 169
  malignant, 425
  of umbilicus, 959
  pyogenicum, 466
  telangiectodes, 466
Granulomatous infection, 125
Graves' disease, 479
Gravitation paraplegia, 766
Grawitz tumor, 203, **499**, **1241**
Great toe, sesamoid of, fracture, 328
Greenstick fracture, 255
    of clavicle, 280
Grenade wounds of chest, 879
Gridiron incision, 954, **972**
    for appendectomy, *1110*, 1112
Gritti-Stokes amputation of leg, 658
Grocco's paravertebral triangle of dulness in purulent pleurisy, 915
Groin, acute lymphadenitis, 423
  glands, tuberculous disease, 425
  spica bandage, 525
Grooved directors, 600
Gros-nez, 176
Gross, 1158
Gross and Carliss, 1154
Ground itch, 62
Guillotine amputation, 647
    through thigh, *648*
  method of aseptic intestinal anastomosis, 1092
Guinea-worm, 62
Guleke, 782, 783
Gum-acacia solution, Bayliss, as substitute for blood-transfusion, 93
Gum-boil, 807
Gum-salt solution, Bayliss, in shock, 116
Gumma, 162
  of bones, 238
  of spine, 778
  of sternomastoid muscle, 856
  of testis, *1285*
  syphilitic, of brain, 717
Gumma tuberculosum of face, 795
    tuberculous, 467
Gummatous orchitis, 1285
  osteo-arthritis, 339
  osteochondritis, 339
Gums, cancer, 210
  hyperplasia, 819
  inflammation, 818
  lancet, 595
  polypus, 819
Gunn's law in treatment of dislocations, 350
Gunshot fractures of skull, 674
  wounds, 36, 40, **44**
  Carrel-Dakin treatment, 54
    of abdomen, 963
    of bones predisposing to fractures, 259
    of face, 791
    of joints, treatment, 351
    of neck, 850
    treatment, 45
Gunstock deformity, 288
Gussenbauer, 1045
Gussenbauer's intestinal suture, *1087*
Gustatory artery, ligation, 630
Gutter fractures, 255
Gwathmey, 542, 545
Gwathmey's tube, *544*
Gye, 184
Gynecomastia, 889

Habitual dislocation, 349
Haden, 512
Haden, Orr, and Whipple, 1058
Hagedorn needles, *602*
Haggard, 502
Hahn's cannula, 843
  pylorodiosis, 1047
Hair, superfluous, 462
Hair-ball in stomach, 1003
Hairy matrix cancer, 471
Hall's method of artificial respiration, 500
Hallion and Tuffier, 878
Hallux flexus, 1311
  rigidus, 1311
  valgus, 1311
  varus, 1311
Halstead, 18, 496
Halsted, 134, 404, 611, 627, 1090
Halsted's forceps, 600, *601*
  incision in breast cancer, *905*
  intestinal suture, *1085*, 1087
  retractors, 602
Halsted-Reverdin method of skin-grafting, 615
Hamilton, 598
Hammerfahr, 1155
Hammer-toe, 1310
Hammock-operation, Coffey's, 1048
Hammond wire splint, 277, 532
Hanche à resòrt, 1300
Hand, accoucher's, in gastric tetany, 1031
  amputation, 650
  bifurcation, 1292
  claw-, 447, **455**
  cleft, 1292
  club-, 1291
  in acromegaly, *495*
  lobster-claw, 1292
  palm, foreign bodies in, 1297
  partial giantism, 1292
  phantom, 644
  sterilization, 581
    Furbringer's method, 281
  trident, 227
  tuberculosis, 1299
Handkerchief bandage, 529
Handley, 208, 899, 984
Handley's incision in breast cancer, *905*
  lymphangioplasty, 420, 909
  lymphangiorrhaphy for ascites, 994
Hanot's cirrhosis, 1127
Hansen, 173
Hard-baked spleen, 425
Harding, 193, 200, 421, 798, 1279
Harelip, 784, **705**
  complete, 786
  complicated, 786
  double, 786
  incomplete, 786

Harelip, median, 786
  single, 786
Harrington, 1090
Harrington's solution, 135
Harris, 55
Harrison's groove, 834
  sulcus, 224
Hartman, 1080, 1084, 1118
Hartman's line for division of stomach in partial gastrectomy, *1041*
Harvest bug, 60
Hauser, 1082
Hawley's fracture table, *265*
Hayem-Widal type of hemolytic icterus, 1160
Haynes' operation in basilar meningitis, 689
Head, 429. See also *Skull*.
  four-tailed bandage, 527
  hot-cross-bun, 224
  recurrent bandage, *523*, 524
  square, 683
  swelled, 170
  tetanus, 150
Head-and-neck actinomycosis, 171
Headache after spinal anesthesia, 573
  in tumors of brain, 715
  puncture, 509
  spinal, 738
Healing of wounds, 39. See also *Wounds, healing*.
  sore, 29
  ulcer, 29
Heart, 943
  anomalies, congenital, 943
  arrested, treatment, 947
  circulation, control of, 949
  cysts, 947
  disease and toxic adenoma of thyroid gland, 484
    cholecystitis and, differentiation, 1139
    hydrothorax in, 912
  drug injections, 947
  electrical stimulation, 947
  exposure, Duval Barasty incision for, *949*
    operative, 949
  hemorrhage from, control of, 949
  massage, **502**, 948
    Babcock's digital method, 948, *948*
    subdiaphragmatic, 948
    transdiaphragmatic, 948
    transthoracic, 948
  mobile, 943
  movable, 943
  needling, 947
  operations, anesthesia in, 947
    technic, 947
  orifices, operations on, 946
  resuscitation, 947
    by physiologic saline with epinephrin in blood-stream, 947
  suturing, 948
  tamponade, 944
  tumors, 947
  valves, operations on, 946
  wandering, 943
  wounds, 943
    cardiorrhaphy in, 944
    hematothorax in, 944
    hemopericardium in, 944
    prognosis, 944
    symptoms, 944
    treatment, 944
Heart-failure, 943
  acute, 943
Heat as symptom of inflammation, 22
  as counterirritant, 516
  disinfection, 129
  division or destruction of tissue by, 597
  in arrest of hemorrhage, 82
  in treatment of inflammation, 23
  local effects, 66
Heberden's nodes in osteo-arthritis, 341
Hedblom, 932, 941, 1205
Hedonal intravenous anesthesia, 553
Heel, big, 1304
  painful, 387, 435, 1310
  policeman's, 387, 1310
Heel-in-axilla treatment of dislocation of scapula, 357
Heidbrink anesthesia machine, *550*
Heineke, 1045
Heineke-Mikulicz pyloroplasty, 1049
Heister's valves, 1134
Helferich, 344
Heller, 148
Helminthes, 61
Hemangioma, 193
  cavernous, 469
  of chest, 884
  of face, 799
  of neck, 857
  raised, 469
Hemarthrosis, 330, 331
Hematemesis, 1023
  hemoptysis and, differentiation, 1023
Hematocele, 1284
  encysted, 1284
  hernia and, differentiation, 1169
  vaginal, 1284
Hematogenous infection of gall-bladder, 1135
Hematoma, 37, 78
  arterial, treatment, 46, 88
  bursal, 387
  fungus, 469
  of appendix epiploica, *1084*
  perirenal, 1227
  pulsating, of bone, 253
  subaponeurotic, 665
Hematomyelia, 767
Hematorachis, 766
Hematothorax, 912
  in heart-wounds, 944
  treatment, 880
Hematuria, 1223
  essential, 1223
  in acute appendicitis, 1100
  prostatic, 1223
  ureteral, 1223
  urethral, 1223
  vesical, 1223
Hemihypertrophy, congenital total, 223
Hemimacrosomia, 223
Hemimelus, 1288
Hemiplegia, 391
Hemiptera, diseases produced by, 60
Hemithyroidectomy, 488
Hemoclastic crisis of Widal in hepatic disease, 1120
Hemoglobinuria, 1224
Hemolytic icterus, 1129, **1160**
  acquired, 1160
  Chauffard-Minkowski type, 1160
  congenital, 1160
  Hayem-Widal type, 1160
Hemopericardium in heart-wounds, 944
Hemoperitoneum after injury, significance of, 961
Hemophilia, 89
  bleeder's joint in, 331
  treatment, 90
Hemoptysis, hematemesis and, differentiation, 1023
Hemorrhage, 77
  after tonsillectomy, treatment, 89
  and shock, 115
  arrest of, 78
    anastomosing collateral circulation, 85
    cauterization, 83
    chemical coagulants and astringents, 83
    cold, 82
    elevation, 83
    endotherm knife, 83
    forcipressure, 84
    heat, 82
    in incised wounds, 38
    in lacerated wounds, 41
    ligation, 84
    natural, 79
    organic coagulants, 83
    position, 83
    pressure, 83
    radium knife, 83
    styptics, 83
    torsion or twisting, 83
  arterial, 77
    acupressure for, 86
    primary, treatment, 87
    recurrent, treatment, 87
    secondary, treatment, 46, 87
    treatment, 46, 87
  by diapedesis, 78
Hemorrhage by rhexis, 78
  capillary, 77
    treatment, 88
  complicating operations on thyroid, 488
  cranial, treatment, 89
  deep, 78
  diagnosis, 79
  digital compression in, 80
  external, treatment, 46
  extradural, 706
  following gastro-enterostomy, 1022
  from bladder, treatment, 89
  from bony foramina of skull, control, 705
  from brain, 701
    control, 705
    extradural, 706
    in newborn, 707
    treatment, 89, 704
  closed visceral injury, 961
  diploë, control, 705
  duodenal ulcer, 1015
  dura, control, 705
  esophagus, 864
  heart, control of, 949
  internal carotid artery, 706
  middle meningeal artery, 706
  navel, 958
  nose, treatment, 89
  pharynx, 830
  pia, control, 705
  rectum, treatment, 89
  scalp, control, 705
  stomach, 1023
    treatment, 89
  tongue, treatment, 88
  tooth socket, treatment, 88
  varicose veins, treatment, 418
  in acute appendicitis, 1105
  in fracture of base of skull, 679
  in gunshot wounds of face, 792
  in penetrating wounds of chest, 878
  in wounds of chest, treatment, 880
  increased tendency to, 79
  intermediary, 78
  internal, postoperative treatment, 591
    treatment, 88
  intestinal, from ulcer in typhoid, 1071
  into joint, 331
  into pleura, 913
  intracranial, 701
    of newborn, 707
    operation for, methods of controlling hemorrhage during, 705
    treatment, 704
  pathology, 78
  postoperative, in appendicitis, 1114
  primary, 78
  prognosis, 80
  pulmonary, 927
  reactionary, 78
  secondary, 78
    treatment, 86
  spinal, 766
    extramedullary, 766
    intramedullary, 767
  spontaneous, into skin, 460
  subcutaneous, 78
  submucous, 78
  symptoms, 79
  tourniquet for, 81
  treatment, 46, 80, 87
    emergency, 80
  varieties, 77
  venous, 77
    treatment, 88
  vesical, treatment, 89
Hemorrhagic ascites, 994
  blebs in fractures, 261
  exudate, 20
  infarction, 78
  pachymeningitis, external, 706
    internal, 687
  pancreatitis, acute, perforated peptic ulcer and, differentiation, 1011
  sarcoma, multiple, 470
Hemorrhagin of snake venom, 58
Hemorrhoids, 194, 414, **1212**
  clamp-and-cautery operation, 1213
  external, 1212
  internal, 1212
  Kelsey's clamp for, *1213*

Hemorrhoids, sentinel, 1211
thrombotic, external, 412, 1212, *1213*
Whitehead's operation, 1213
Hemostasis, 77
intravenous therapy, 513
provisional, 82
temporary, 82
Hemostatic forceps, 600
Kelly's, *601*
Kocher's, *84*
Hemostats, 84, 600
Hempel, 416
Henderson, 260, 502, 552
Henderson's theory of shock, 113
Hendon, 511
Henle, 878
Henoch's purpura, 460
Henpuys, 176
Hepatic deficiency, treatment, 1121
disease, tests for, 1119
jaundice, 1129
Hepaticoduodenostomy, 1147
Hepaticus, obstruction of, 1149
Hereditary hypoplasia of mesenchyme, *224*, *225*
Hernia, 960, **1165**
acquired, 1166
cecal, sacless, 1182
cerebri, 723
congenital, 1166
hydrocele and, differentiation, 1168
definition, 1165
diaphragmatic, 1204
congenital, 1204
traumatic, 1204
differential diagnosis, 1168
epigastric, 1202
etiology, 1167
external, 1166
fatal, of tonsillæ into foramen magnum from spinal puncture in internal hydrocephalus, *698*
fatty, 192
femoral, 1166, *1171*, *1172*, *1173*, *1174*, **1193**
cysts of femoral canal and, differentiation, 1197
in man, *1196*
in woman, *1197*
inguinal hernia and, differentiation, 1183
Moschowitz's operation, 1198
operation, 1198
preacetabular bursitis and, differentiation, 1197
psoas abscess and, differentiation, 1197
saphenous varix and, differentiation, 1196
subperitoneal lipoma and, differentiation, 1197
taxis in, 1198
trusses in, 1197
funicular, 1178
hematocele and, differentiation, 1169
hydrocele and, differentiation, 1168
incarceration, 1173
incisural, 1167, **1202**, *1203*
infantile, 1178, *1179*
encysted, 1178
inflammation, 1172
inguinal, 1166, **1177**, *1184*, *1185*
Andrews' operation, 1193
Babcock's operation, 1186, *1187*, *1188*, *1189*, *1190*, *1191*, *1192*, *1193*, *1194*
Bassini's operation, 1186
complete, 1177
congenital hydrocele and, differentiation, 1183
diagnosis, 1183
direct, 1179
acquired, 1177
encysted hydrocele and, differentiation, 1184
enlarged inguinal glands and, differentiation, 1184
femoral hernia and, differentiation, 1183
Ferguson's operation, 1191
hydrocele of tunica vaginalis and, differentiation, 1184
incomplete, 1177
indirect, 1177, *1180*
Hernia, inguinal, indirect, acquired, *1181*, *1182*
in woman, *1195*
interparietal, 1181
interstitial, 1181
lateral, 1177
oblique, 1177
postoperative treatment, 1191
potential, 1178
preacetabular bursitis and, differentiation, 1184
properitoneal, 1181
psoas abscess and, differentiation, 1183
saphenous varix and, differentiation, 1183
strangulated, in infants, 1176
testicular growths and, differentiation, 1184
treatment by truss pressure, 1185
operative, 1185
undescended testicle and, differentiation, 1183
varicocele and, differentiation, 1183
internal, 1204
interstitial, 1166
into umbilical cord, 957, *957*
irreducible, 1167, *1170*, **1171**
Littré's, 1167
lumbar, 1203
manipulative reduction, 1169
obstruction, 1173
obturator, 1203
of abdominal wall, 960
of breast, plastic operation for, 910
of lung in wounds of chest, 879
of muscle, 381
of urinary bladder, 1182
par glissement, 1167
pathologic conditions, 1171
pectineal, of Cloquet, 1196
perineal, 1204
postincisional, 1202
postoperative, 1167
properitoneal, 1166
rectal, 1215
reducible, 1167
retroperitoneal, 1204
Richter's, 1167
sciatic, 1204
scrotal, 1166, *1170*, **1180**, *1184*, *1185*
sliding, 1167, **1182**
of sigmoid, 1182
strangulated, *1171*, 1173, *1174*, *1175*
appendicitis and, differentiation, 1104
fecal vomiting in, 1174
herniotomy for, 1176
intestinal stricture after, 1066
postoperative obstruction, 1177
structure, 1165
symptoms, 1168
taxis of, 1169
traumatic, 1167
treatment, 1169
mechanical, 1169
operative, 1170
trusses for, 1169
umbilical, 1198, *1199*
Babcock's interdigitation operation, 1199
congenital, 1198
infantile, 1198
Mayo's operation, 1199, *1200*
of adults, 1199
repair by layer closure, 1200
vertical imbrication for, 1199, *1200*
with obese and relaxed abdominal wall, operation for, *968*, *969*, *970*, *971*, *972*
vaginal, 1178
varicocele and, differentiation, 1168
varieties, 1166
ventral, 1200
lateral, 1201
median, 1200
Hernial aneurysm, 394
Hernioplasty, 1170, 1185
Babcock's, 1186, *1187*, *1188*, *1189*, *1190*, *1191*, *1192*, *1193*, *1194*
for inguinal hernia, 1185
for umbilical hernia, 1199
Herniorrhaphy, 1170
Herniorrhaphy for inguinal herniæ, 1185
Herniotome, 595
Cooper's, 1170
Herniotomy, 1170
for strangulated hernia, 1176
Herpes zoster, 434
Herpetic eruption on penis, 1280
Hersage, 438
Hertzler, 388, 389
Hesselbach's triangle, obliteration of, in hernioplasty, *1190*
Heterologous osteoma, 242
Heteroplastic operation for closure of defects of skull, 686
Heuer, 498
Heully, 1301
Heusner's glue, 267
Hexylresorcinol in urinary infections, 128
Hey, 599
Hey's amputation of foot, 655
Hibbs, 769
Hiccup, postoperative treatment, 590
Highsmith, 1090
Hilton, 27, 828, 881
Hilton's method of treating abscess, 27
treatment of palmar abscess, 1299
of perivascular infection of carotid sheath, 854
Hindgut, 1053
Hinman, 1285
Hip, jumping, 1300
snapping, 1300
springing, 1300
Hip-joint amputation, 659
Jordan's, *659*
Kocher's, *659*
Larrey's, 659
arthrotomy, 343, 345
Campbell's operation, 371
congenital dislocation, 372. See also *Dislocation of hip, congenital.*
contusions, 371
disarticulation, *659*
dislocation, 366. See also *Dislocation of hip.*
fixation, in morbus coxarius, test for, *336*
fracture, optimum position for ankylosis, 265
operations, 371
reconstructive operations on, 371
Smith-Peterson incision for, 371
sprain, 371
tuberculosis, congenital, dislocation and, differentiation, 372
Sprengel's incision for approach, 371
Hippocratic face, 980
fingers, 229
Hirschel, 554, 577
Hirschsprung's disease, 1055, *1056*
evacuation of colon in, 1057
Hirsuties, 462
Hirtschler, 1310
Histrionic spasm, 733
Hobnail liver, 1126
Hochsinger, 166
Hodgen's splint, *267*
Hodgkin, 425
Hodgkin's disease, 197, **425**
Hoff and Eppinger, 946
Hoffman, 598
Hoffman's sign in gastric tetany, 1032
Hoffman and Schaudinn, 161
Hoffmeister-Finsterer method of partial gastrectomy, 1039
Hoke, 1309
Holmes, 533
Holocain hydrochlorid, local anesthesia by, 560
Homes, private, operations in, 583
Homologous osteoma, 242
Homoplastic operation for closure of defects of skull, 686
Honeymoon palsy, 450
Hookworm, 62
disease, 62
Horn, 462
cicatricial, 205, **798**
cutaneous, 205
nail, 205
of face, 798
sebaceous, 205, 798
wart, 205, 798

Horned men, 176
Horner's syndrome, 737, 742
Hornifying squamous epithelioma, 210
Horse-flies, irritation of skin from, 59
Horse leech, 61
Horseshoe fistula, 1209
  kidney, 1222
  tourniquet, 82
Horsley, 1019
Horsley's wax, 133
Hospital gangrene, 109
Hot abscess, 27
  air disinfection, 129
  water disinfection, 130
Hot-cross-bun head, 224
Hour-glass chest, 873
  organic, in gastric ulcer, 1007
  stomach, 1029
    with gastric ulcer, *1029*
Housemaid's knee, 220, **387**, 390
Howard's method of artificial respiration, 500
Hudson, 599, 704
Hullihen, 792
Humerus, bone cyst, *221*
  dislocation, 353
  epiphysis, lower, separation of, 289
    upper, separation of, 284
  fracture, 282. See also *Fracture of humerus.*
  osteogenic sarcoma, 246
  osteosarcoma, *244*
Hunch-back, 770
Hunger, constant, 1033
  excessive, 1033
Hunger-pain, 998
  in duodenal ulcer, 1013
Hunt, 543
Hunter, 403, 783, 1062
Hunter's canal, ligation of femoral artery in, 637
  operation for aneurysm, *403*
Hutchinson's teeth, 163, *811*
    characteristics, *164*
  wart on tongue, 822
Hydatid cysts, 64, 222
    of chest wall, 884
    of liver, 1124, *1125*
      hydrated thrill in, 1125
    of lung, 935
    of pancreas, 1153
  disease of bone, 239
  uterine, 188
Hydatidiform mole, 188
Hydradenitis of Verneuil, 144
Hydrarthrosis, 331
  syphilitic, 338
    of knee, 339
Hydrated thrill in hydatid cysts of liver, 1124
Hydrencephalocele, 871
Hydrocele, *1169*, 1282
  acquired, 1282
  bilocular, 1282
  congenital, hernia and, differentiation, 1168
    inguinal hernia and, differentiation, 1183
  diffuse, of spermatic cord, 1282
  encysted, inguinal hernia and, differentiation, 1184
    of epididymis, 1283
    of spermatic cord, 1282
    of testes, 1284
  funicular, 1282
  hernia and, differentiation, 1168
  infantile, 1282
    of spermatic cord, 1283
  of canal of Nuck, 1282
  of epididymis, 1282
  of neck, 427
  of round ligament, 1282
  of testis, 1282
  of tunica vaginalis, inguinal hernia and, differentiation, 1184
  vaginal, 1282
    primary chronic, 1283
Hydrocephalus, 694
  congenital, 694, *695*, *696*
  Dandy's operation, 697
  external, 694, **699**
  internal, 694
    acquired, 697
    idiopathic, 697
Hydrocephalus, internal, secondary, 697
    treatment, 699
    primary, 694
Hydrochlorid of quinin and urea, local anesthesia by, 560
Hydrogen peroxid as disinfectant, 136
Hydronephrosis, 220, 1233
Hydroperitoneum, 21, 993
  after injury, significance of, 961
Hydrophobia, 153
Hydropneumoperitoneum after injury, significance, of, 961
Hydrops articuli, 331
  bursal, 387
  of gall-bladder, 1131, *1132*, *1133*, 1136
Hydrorrhea nasalis, 696
Hydrosalpinx, 220
Hydrostatic test for rupture of bladder, 1251
Hydrothorax, 21, 912
  egophony in, 912
  in heart disease, 912
  in pulmonary tuberculosis, 912
  tuberculous, 935
Hygroma, 197, 801
  bursal, 387
  congenital cystic, of neck, *845*
  cystic, 427
  sacral, 757
Hyoid bone, acute periostitis, 850
    fracture, 850
    tumors 850
Hyperacusis, 734
Hypercapnia in anesthesia, 534
Hyperchlorhydria, 1033
  dyspepsia of, 998
Hypercholesteremia as cause of gallstones, 1133
Hyperemia, active, in inflammation, 23
  passive, in inflammation, 23
  test for impending gangrene, 94
Hyperglycemia in diabetes, 122
  in pancreatic disease, 1150
Hypermotility of stomach, 1033
Hypernephroma, 203, 499, **1241**
  of bones, 254
Hyperosmia, 725
Hyperostosis, 189, 241
Hyperplasia, 22
  of adrenals, 498
  of gums, 819
  of nails, 473
  of palatine tonsils, 832
  of thymus, asphyxia in, *489*
Hyperplastic tuberculosis of intestines, 1077
Hyperpnea, 113
Hyperthyroidism, 479
  roentgen rays in, 517
Hypertonic stomach, *1025*
Hypertrichosis, 462
  sacrolumbar, 757
Hypertrophic arthritis, 340
  biliary cirrhosis, 1127
  emphysema, 930
  pulmonary arthropathy, 229
    osteo-arthropathy, 190
  stenosis of pylorus, 1031
Hypertrophy, congenital, of foot, 1300
  endemic, of os calis, 1304
  of breast, 188, *888*, **889**
  of colon, 1055
  of fingers, 1289, **1292**
  of palatine tonsils, 832
  of prostate, 1273
    roentgen rays in, 517
  of pylorus, congenital, 999
  of spleen, 1159
  of stomach, 1026
  of thymus, 489
    roentgen rays in, 517
  of toes, 1289
  of tongue, 819
Hypochlorhydria, 1033
Hypochloridemia in intestinal alkalinosis, 1060
Hypodermic injection, 505
Hypodermoclysis, 507
  continuous, 507
Hypogastric artery, digital compression, 80
    ligation, 635
Hypoglossal anastomosis, 733
  nerve, lesions, 737
Hypoglycemia in diabetes, 122, 123
Hypophysis cerebri, adenoma, 495
    anatomy, 490
    anterior lobe, 490
    cancer, 496
    cyst, *492*
    diseases, 490
    dysfunction, 492
    implantation in hypopituitarism, 498
    middle lobe, 490
    operations on, 496
      intradural approach, 497
      subtemporal decompression, 496
      transphenoidal approach, 496
    posterior lobe, 490
    sarcoma, 496
    tumor, *493*, 495
Hypopituitarism, anterior-lobe type, 490
  posterior-lobe type, 492
  posttraumatic, *491*
Hypoplasia, hereditary, of mesenchyme, 224, 225
  of adrenals, 498
  of breast, 888
  of kidney, 1222
  of laryngeal cartilages, 833
  of mandible, 805
Hypospadias, 1278
  balanic, 1278
  penile, 1278
  perineal, 1278
  scrotal, 1278
Hypothenar space, abscess, 1299
Hypothyroidism, 477
  congenital, 478
  preadolescent, 478
Hypotonic stomach, *1025*
Hypsicephalic skull, 669
Hysterical joints, 342

Ice-tongs in fractures, 269
Ichthyol, 139
Icterus, 1128
  index, 1130
  hemolytic, 1160
    acquired, 1160
    Chauffard-Minkowski type, 1160
    congenital, 1160
    Hayem-Widal type, 1160
Ideal band, 990
Idiopathic aneurysm, 394
  dilatation and hypertrophy of colon, 1055
  facial spasm, 733
  multiple pigmented sarcoma of Kaposi, 470
  tetanus, 149
Ileocecal cysts, congenital, 1076
  intussusception, 1062
  valve, incompetent, Kellogg's operation for, *1089*
Ileocolic intussusception, 1062
  vein, ligation of, Braun's operation, 1124
Ileum, blood-supply, *1096*
  diverticula, *1075*
Ileus, 1058
  gastromesenteric, acute, 1061
  in acute appendicitis, 1100
  inflammatory, in peritonitis, 980
  postoperative, in appendicitis, 1116
Iliac abscess, 770
  artery, common, ligation of, 635
    external, aneurysm, *394*
      digital compression, 80
      ligation of, 636
    internal, ligation of, 635
Iliohypogastric nerve, 953
Ilio-inguinal nerve, 953
Iliopectineal dislocation of hip, 367
Iliopsoas bursa, inflammation, 390
  right, in acute appendicitis, 1100
Imbrication of abdominal wall, 967
  vertical, for umbilical hernia, 1199, *1200*
Immovable bandage, 530
Immunity, acquired, 125
  artificial, 128
  natural, 125, **128**
  to infection, 125
Immunization, non-specific, 513

Impacted fractures, 256
Impaction, fecal, 1207
fracture of calcaneus, 326
Imperforate anus, 1206
mouth, 784
rectum, 1206
Implantation, endometrial, in small intestine, 1079
pituitary, 498
Incised wounds, 36, **38**
after-treatment, 39
Incision, abdominal, 972
relation to abdominal nerves, 954
appendectomy, *1108*
appendiceal, 972
Battle-Jalaguier-Kammerer, 972
Battle's, for appendectomy, 1114
Bevan's, 974
breast, Thomas-Warren, *890*
coronal, for operations on skull, *704*
Cushing's cross-bow, in brain tumors, 719, *720*
Davis, 972
for appendectomy, 1114
Duval Barasty, *949*
for resection of kidney, *1230*
gall-bladder, 974
gridiron, 954, **972**
for appendectomy, *1110*, 1112
Jaboulay's, 972
Kocher's, 974
Lennander's, 972
Maunsel's, for resection of intussusceptum, 1063
Mayo-Robson, 974
McArthur's appendiceal, 972
gall-bladder, 974
McBurney's, 972
for appendectomy, *1110*, 1112
Morrison's, 974
of kidney, 1242
of renal pelvis, 1242
of seminal vesicles, 1277
Perthes's angular, 974
Pfannenstiel's, *973*, 974
rectus, 972
skin for cancer of breast, *905*, 908
transrectus, 972
vertical median, of abdomen, 972
paramedian, of abdomen, 972
pararectus, 972
Incisura in gastric ulcer, 1007
Incisural hernia, 1167, **1202**, *1203*
Babcock's silver chain for, 1203
Inclusio fœtus in fœtu, 757
Incontinence of feces, 1207
of overflow of urine, 1248
of urine, 1247
false, 1248
nocturnal, 1247
passive, 1248
Index, altitudinal, 669
cephalic, 669
energy, for operability, 537
icterus, 1120
Moot's, for operability, 537
of malignancy of cancer, 208
India, fungus-foot, 175
Indian method of rotation of skin flaps, 613
Indigo-carmine test of renal function, 1225
Indirect fractures, 257
Indolent bubo, 161
Indurative mediastinopericarditis, 938
Infantile breast, 888
hernia, 1178, *1179*
encysted, 1178
hydrocele, 1282
of spermatic cord, 1283
scurvy, 224
umbilical hernia, 1198
Infantilism, *491*
Lorain type, *491*
Infarction, hemorrhagic, 78
of spleen, 1159
Infection, 125
acute, of face, 793
axillary, 881
Bacillus coli communis, 146
pyocyaneus, 147
chronic, of face, 794
follicular, of axilla, 144
gangrenous, 125
Infection, gas, 125
gas-bacillus, 148
granulomatous, 125
immunity to, 125
in gunshot wounds of face, 792
necrotizing, 125
of bone, 230
of chest wall, 880
of wounds, 54
perivascular, of carotid sheath, 853
pneumococcus, 146
proliferative, 125
pyogenic, 125
secondary, in chest wounds, treatment, 880
serohemorrhagic, 125
special types, 125
Spironemata, 160
Staphylococcus pyogenes, 141
Streptococcus pyogenes, 143
local, 144
subaponeurotic, of scalp, 668
surgical, acute, 141
chronic, 158
theory of cancer, 207
through blood-stream, 126
toxic, 125
treatment, 126
Infectious pus, 26
Infiltration anesthesia, 534, **554**
with cocain, 557
round-cell, 20
Inflammation, 20
active hyperemia in, 23
acute, 21
treatment, 23
adhesive, 21
agglutinative, 21
baking in, 23
Bier's treatment, **23**, 24
catarrhal, 21
cell multiplication in, 20
characteristic lesion, 21
chronic, 21
of thyroid gland, 476
treatment, 23
classification, 21
counterirritation in, 24
croupous, 21
degenerative, 21
desquamative, 21
diathermy in, 23
diphtheritic, 21
dominant lesion, 21
etiology, 21
extension, 22
exudative, 21
gangrenous, 21
general reaction in, 22
heat as symptom, 22
in treatment, 23
interstitial, 21
lymphatic changes in, 20
malnutrition in, 20
mucopurulent, 21
of acromial bursa, 390
of appendix, 1095
of arteries, 391
of bile-ducts, 1149
of bladder, 1254
of blood-vessels, 105
of bone, 230
predisposing to fractures, 258
of breast. See *Mastitis.*
of bursæ, 387
of corpus cavernosum, 1280
of esophagus, 865
of gall-bladder, 1134. See also *Cholecystitis.*
of glans penis, 1279
of gums, 818
of hernia, 1172
of iliopsoas bursa, 390
of intestinal diverticula, 1075
of ischial bursa, 390
of joints, 329, **332**
of larynx, 838
of lymph-vessels, acute, 423
of Meckel's diverticulum, 1055
of mediastinum, 937
of meninges, 687
of muscle, 382
of nails, 474
of nipples, 889
Inflammation of olecranon bursa, 396
of pancreas, 1151
of parotid gland, 828
of peripheral lymph-vessels, 422
of peritoneum, 975
following appendectomy, 1115
of pharynx, 830
of pia-arachnoid, 773
of pleura, 912
of popliteal bursa, 390
of portal vein, 1124
following appendectomy, 1115
of prepatellar bursa, 390
of prostate, 1272
of rectum, 1206
of salivary duct, 825
of seminal vesicles, 1276
of spinal meninges, 773
of subcrural bursa, 390
of subscapular bursa, 390
of synovial membrane, 329
of tendon sheath, 384
of tendons, 387
of testes, 1284
of thyroid gland, 475
of tonsils, 831
of umbilicus in children and adults, 959
in newborn, 959
of urethra, 1260
of veins, 417
pain as symptom, 22
parenchymatous, 21
passive hyperemia in, 23
pathology, 20
phlegmonous, 21
productive, 21, **22**
prognosis, 23
purulent, 21
pustular, 21
redness as symptom, 22
roentgen rays in, 24
round-celled, 21
specific, 21
subacute, 21
surface, 21
swelling as symptom, 22
symptoms, 22
terminations, 22
treatment, 23
ulcerative, 21
vascular changes in, 20
vesicular, 21
Inflammatory edema, 21
exudates, 20
fractures, 258
fungoid neoplasm, 175
ileus in peritonitis, 980
products, 20
stricture of rectum, 1217
Influenza, purulent pleurisy following, 914
thrombosis in, 94
Infraclavicular rupture of brachial plexus, 446
Infraction of metatarsal head, 241
Infusion, intravenous, 510
subcutaneous, 507
vein, 511
Infusoria, 65
Ingham and Robertson, 775
Ingrowing nail, 473
Inguinal canal, *1165*
glands, enlarged, and hernia, differentiation, 1184
hernia, 1166, **1177**, *1184*, *1185*. See also *Hernia, inguinal.*
Inhalation in bronchiectasis, 931
of zinc stearate and other powders, 924
pneumonia in anesthesia, 538
Inhaler, nasal, *549*
Injection treatment of hydrocele, 1283
of varicose veins, 415
Injections, endermic, 505
epifascial, 507
hypodermic, 505
intracardiac, 514
intradural, 509
intramuscular, 507
intraperitoneal, 508
intraserous, 508
intrathecal, 509
intravenous, 510

Injections of thyroid gland, 486
subarachnoid, 509
subcutaneous, 505
subdural, 509
Injuries, 36. See also *Wounds.*
received from fish, 56
from lower animals, 55
from rats, 56
traumatic, 36
Innocent syphilis, 161
Innominate artery, ligation, 625
Inoculation, endermic, 505
Insects, bites of, 58
larvæ of, invasion of tissues by, **58**, 59
suctorial, diseases produced by, 60
Insomnia, postoperative treatment, 590
Inspection of esophagus, 860
Instillation anesthesia, 554
Instruments, bone-cutting, 598
used in operations, 595
Insufficiency, motor, of stomach, 1025
Insulin, 1150
in diabetes, **122** 123, 124
Interacinar pancreatitis, 1153
Intercondyloid fracture of humerus, 288
Intercostal fibrositis, 382
neuralgia, 434, **883**
thoracotomy, 920
Intercuneiform bone, supernumerary, 1304
Interdigitation of abdominal wall, 969
operation, Babcock's, for umbilical hernia, 1199
Interilio-abdominal amputation, Babcock's, 660–663
Keen's, *659*
Interlobar pancreatitis, 1153
Intermetatarsal bone, supernumerary, 1304
Intermittent claudication, 106
fever, Charcot's, 1149
painful limp, 106
Internal gastric fistula, 1004
hemorrhoids, 1212
hernia, 1204
terphalangeal dislocations, 380
joints, fusion, 1293
Interrupted sutures, *603*
Interruption of peripheral nerves, symptoms, 431
Interscapulothoracic amputation, 653
Interstitial appendicitis, chronic, *1107*
hernia, 1166
inflammation, 21
inguinal hernia, 1181
Intestinal. See also *Intestines.*
adhesions, obstruction from, 1068
alkalinosis, 1060
anastomosis, 1090
aseptic, by basting-stitch method, 1090
by guillotine method, 1092
mechanical aids in, 1090
methods, *1092*
suture, 1090
anthrax, 153
carcinoma, 1081
cysts, 1076
gas-, 1076
mucous, 1076
diverticula, 1075
inflammation of, 1075
elimination, 1093
definition, 1088
methods, *1091*
fistula, 958
carcinoma with, 1073
external, 1072
internal, 1073
gases, 1053
hemorrhage from ulcer in typhoid, 1071
ligation, 1088
localization, *1053*, 1054
obstruction, 1058
by pressure from without, 1067
chronic, 1067
following gastro-enterostomy, 1023
from adhesions, 1068
from twisting of bowel, 1064
high, *1059*, 1060
advantages of high enterostomy, *1059*
low, 1060
Intestinal obstruction, preoperative treatment, 585
parasites in appendix, 1097
sarcoma, 1085
schistosomiasis, 63
stasis, chronic, 1068
high, 1005
stenosis, 1069
in tuberculosis, 1069
stricture, 1066
congenital, 1066
from carcinoma, 1066
from inflammation, 1066
from strangulated hernia, 1066
from wounds, 1066
in tuberculosis, 1066
syphilitic, 1066
sutures, *1085*, 1086
suture materials, 1086
tube for enterostomy, *1093*
tumors, 1079
benign, 1079
ulcers in typhoid, 1070
perforation of, 1070
hemorrhage from, 1071
tuberculous, 1076
Intestines, 1053. See also *Intestinal.*
actinomycosis, 1078
chronic, 1078
pyemic, 1078
alvinoliths in, 1061
anomalies, congenital, 1054
in position, 1054
atresia, congenital, 1054
carcinoma of, stricture in, 1067
coproliths in, 1061
currents of Bond in, 1053
foreign bodies in, 1061
from abdominal cavity, 1061
from rectum, 1061
Vienna treatment, 1062
gall-stones in, 1061, *1062*
gas-cysts, 1076
Kellogg's operation, *1089*
large, 1053
Maunsell's operation, 1094
medical concretions in, 1061
Mikulicz's operation, 1092
operations, 1085
preoperative treatment, 585
phosphatic stones in, 1061
phytobezoars in, 1061
resection, aseptic, 1090
sarcoma, 1085
small, 1053
adenoma, 1079
endometrial, 1079
carcinoma, 1081
Courvoisier's syndrome, 1081
lipoma, 1079
myoma, 1079
tumors, 1079
ulcer, 1069
stenosis, congenital, 1054
stones formed in, 1061
stricture, dysenteric, 1066
typhoidal, 1066
syphilis of, tuberculosis and, differentiation, 1077
traumatic injury, 1057
trichobezoars in, 1061
tuberculosis, 1076
enteroperitoneal, 1077
hyperplastic, 1077
stenosis in, 1069
syphilis and, differentiation, 1077
tumors, 1079
viability, 1176
determination of, 1060
Waugh's operation, 1088
Weir's operation, 1090
Intra-abdominal adhesions, 989
Intra-articular fractures, 257
Intracanalicular fibroma, 187
myxoma, 188
Intracapsular fractures, 257
Intracardiac injection, 514
Intracotyloid dislocation of hip, 367
Intracranial hemorrhage, 701
of newborn, 707
operation for, methods of controlling hemorrhage during, 705
treatment, 704
Intradural anesthesia, 561
Intradural injection, 509
Intramammary abscess, *889*, 892
Intramuscular injection, 507
Intraperitoneal blood-transfusion, 508
injections, 508
Intraserous injections, 508
Intrathecal injection, 509
Intrathoracic disease, 874
goiter, 475
Intratracheal insufflation anesthesia, 545
Intra-uterine fractures, 258
Intravenous anesthesia, 553
infusions, 510
injections, 510
nutrition, 511
osmotherapy, 512
therapy, 511
anaphylaxis in, 514
dangers, 514
ergotropic, 513
for bactericidal action, 513
for bacteriostatic action, 513
for hemostasis, 513
for stimulation, 511
non-specific protein, 513
parenteral alterative, 513
test for susceptibility, 514
to reduce intracranial pressure, 512
to supply fluids, 511
Intraventricular injection of epinephrin, 503
Intussusception, 1062, *1063*
agonic, 1062
colic, 1062
enteric, 1062
following gastro-enterostomy, 1023
ileocecal, 1062
ileocolic, 1062
Maunsell's operation, 1094
postmortem, 1062
retrograde, 1062
Intussusceptum, 1062
resection, Maunsell's incision for, *1063*
Intussuscipiens, 1062
Inverted Trendelenburg position, *1220*
Involution cysts of breast, 896
mastitis, 893
Iodids in syphilis, 166
Iodin as counterirritant, 516
as disinfectant, 133
feeding in exophthalmic goiter, 481
solution as wet dressing for wounds, 50
Iodized oil, injection, into spinal canal, 747
Iodoform, 138
balsam, 139
emulsion, 138
for wounds, 48
gauze, 138
poisoning, 138
Irreducible hernia, 1167, *1170*, **1171**
Irrigation, colonic, 505
of bladder, Janet's method, 1256
Irritable ulcers, 29
of anus, 1211
treatment, 32
Irritation, cerebral, 707
theory of carcinoma, 206
Ischemic contracture, 1294
myositis, 1294
paralysis, 433
Ischial bursa, inflammation, 390
Ischiatic dislocation of hip, 368
Ischiorectal abscess, 1208
Ischium, fracture, 303
Ischuria paradoxa, 1248
Island flaps, 610
Isopral intravenous anesthesia, 553
Israel, 170
Issue, caustic, 516
knife, 516
Issue-peas, 516
Italian method of transfer of skin flaps, 613
Itch, ground-, 62
Itch-mite, bites of, 60
Itrol, 136
Ivory osteoma, 242
Ixodes, bites of, 60

Jaboulay, 783, 1045
Jaboulay's incision, 972

Jackson, 533, 835, 852, 999
Jackson's aspirating bottle, *925*
bronchoscope, *925*
esophagoscope or gastroscope, *861*
forceps, *925*, *926*
I incision in breast cancer, *905*
laryngoscope, 835
membrane, **990**, 1068
probe, *925*
tracheotomy tube, *843*
veil, 1068
Jacksonian epilepsy, 708
Jacob, 214, 902, 903
Jacob's ulcer, 214, **471**
Janet's method of vesical irrigation, 1256
Jaundice, 1128
acholuric familial, 1160
biliary, 1128, *1129*
glucose deficiency in, 1128
hemolytic, 1129
hepatic, 1129
obstructive, 1128, *1129*
clinical symptoms, 1130
tests for, 1120
treatment, 1121
Javel's solution, 134
Jaw, 805
and face, actinomycosis, 812
angle, abscess of, 853
ankylosis, 806
arsenical necrosis, 809
periostitis, 809
big, 170
clacking, 351
congenital anomalies, 805
malformations, 785
exanthematous necrosis, 810
fibrocystic disease, 814
fracture, **275**, 276
lower, cancer of, 816
dislocation, 351
subluxation, 351
lumpy, 170
mercurial periostitis, 809
osteogenic sarcoma, 246
osteomyelitis, 807, **808**
periostitis, 808. See also *Periostitis of jaw.*
phosphorus necrosis, 809
periostitis, 809
phossy, 809
prognathous, 805
radium paresthesia, 850
roentgen-ray paresthesia, 850
syphilis, 810
tuberculous osteitis, 810
periostitis, 810
upper, cancer, 816
chondroma, 816
fibroma, 816
osteoma eburnum, 816
sarcoma, 816
tumors, 816
Jeger, 951
Jejunal fistula, 1074
obstruction following gastro-enterostomy, 1021
toxemia, in peritonitis, treatment, 984
postoperative, in appendicitis, 1116
ulcer, 1019
perforated, 1020
Jejunocolostomy for jejunal toxemia in peritonitis, 984
Jejunostomy, 1048
Coffey's, 1048
Maydl's, 1048, **1089**
Mayo-Robson, 1048
Witzel's, 1048
Jeller, 868
Jigger flea, 60
Joffroy's sign in exophthalmic goiter, 480
Joint sensation, 429
tibiotarsal, Volkmann's congenital deformity, 1304
Joint-mice, 332
Joints, adhesions within, 342
artificial, formation of, 344
bleeder's in hemophilia, 331
Brodie's, 342
capsulorrhaphy, **345**
Charcot's, 340
in children, **340**
Joints, Clutton's, 339
cysts, 343
diseases, 329
examination, 329
excision, 344
fractures, 257
gunshot wounds, treatment, 351
hemorrhage into, 331
hysterical, 342
incisions into, 343
inflammation, 329, **332**
interphalangeal, fusion, 1203
loose bodies in, 332
melon-seed bodies in, 332
neuralgic, 342
neuromimetic, 342
operations upon, 343
rice-bodies in, 332, **335**
stiffness, 342
syphilis, 338
transplantation, 345, **620**
tumors, 343
von Gies', 339
wounds of, treatment, 42, **45**
Jones, 164, 264, 459, 1045
Jones' crab cock-up splint, *297*
humerus-traction-splint in fracture of shaft of humerus, 287
operation for dislocation of medial meniscus of knee, 375
for extensor paralysis of wrist, 386
Stiles' modification, 386
position in fractures about elbow, 289
short cock-up splint, *299*
Jonnesco, 946, 947
Jonnesco's operation in angina pectoris, 947
Jordan and Lahey, 1008
Jordan's amputation of hip, *659*
of shoulder, 653
disarticulation of hip, *659*
Joyce, 620
Jugular vein, internal, thrombosis of, 96
Jump, 499
Jumper's sprain, 381
Jumping hip, 1300
Jutte tube, 504
Juvenile deforming metatarsophalangeal osteochondritis, 241, 328
gangrene, 105
tabes, 340
Juxta-articular nodules, 343

Kader, 1045
Kader's gastrostomy, *1046*, 1047
Kanavel, 496, 507, 1299
Kandahar sore, 178
Kangri cancer, 213
Kaninloma, 180
Kaposi's sarcoma, 470
treatment, 804
Kappis, 578
Katayama disease, 63
Keatley, 271
Keen, 409
Keen's interilio-abdominal amputation, *659*
point, 699
Keith, 114
Keith's perineal litholopaxy, 1254
Kellogg's operation for incomplete ileocecal valve, *1089*
Kelly, 601
Kelly's hemostatic forceps, *601*
lipectomy of abdominal wall, 971
Kelly-Péan forceps, 600
Keloid, **54**, 187
following traumatism, *186*
of chest, 884
of face, 798
treatment, 55
Kelsey's hemorrhoidal clamp, *1213*
Kendall, 475
Kentish's ointment, 140
Kentrotribe, Mikulicz's, 1093
Keratosis senilis, 462
Kerr, Coffey, and Brown, 947
Ketosis in anesthesia, 535
Key, 225
Kidney, 1222. See also *Renal.*
abscess, 1234, **1235**
absence, 1222
ascending tuberculosis, 1237
Kidney cancer, 1241
caseous tuberculosis, 1236
congenital anomalies, 1222
cysts, 1239
decapsulation, 1242
differential diagnosis, 1223
displacements, 1222
effect of spinal anesthesia upon, 564
examination, 1222
Noble's position, 1222
floating, 1227
function, 1225. See also *Renal function.*
fusion, 1222
horseshoe-, 1222
hypoplasia, 1222
in anesthesia, 538
incision, 1242
injuries, 1226
miliary tuberculosis, 1236
movable, 1227
cholecystitis and, differentiation, 1141
myxosarcoma, 1241
needling, 1242
operations on, 1242
position for, 1227
palpation, 1222
pelvic, 1222
pelvis, drainage of, 1242
incision of, 1242
infection of, 1233
tumors of, 1242
percussion, 1223
pneumoradiography, 1225
polycystic, 1239, *1240*
pus-, 1234
regeneration of, 26
resection, incision for, *1230*
rupture, 961
sarcoma, 1241
stones in, 1228
suprarenal rest, 499
tolerance to infection, *1234*
tuberculosis, 1236
tumors, 1240
wandering, 1227
wounds, **1226**, 1227
Kienboch's disease of lunate bone, 299
Killian, 835
Kimpton-Brown method of blood-transfusion, 92
Kinesthetic sense, 429
Kingsley, 277
Kink, Lane's, **990**, 1068
Kinking of epiglottis, 833
Kirk's plastic operation for covering exposed bone after guillotine amputation, *644*
Kirmisson, 943
Kirschlein, 835
Kissing ulcer, 1006
Kitasato, 149
Klapp's method of ether anesthesia, 545
Klose, 489
Klumpke paralysis, 447
Knee, Charcot's, *339*, 340
housemaid's, 220, **387**, 390
internal derangement, 375
knock-, 1302
medial meniscus, dislocation, 375
Jones' operation, 375
rugby, 321
syphilitic hydrarthrosis, 339
Knee-cap, fracture, 317
Knee-joint, arthrodesis, 345
arthrotomy, 343, 345
disarticulation, Smith's, 657
dislocation, 376. See also *Dislocations of knee-joint.*
fracture, optimum position for ankylosis, 265
Knees, congenital dislocation, 374
Knife, endotherm, in arrest of hemorrhage, 83
issue, 516
Martin's fistula, *1211*
radium, in arrest of hemorrhage, 83
Knives, amputating, 595
cartilage, 595
operating, 595
radio, 597
Knock-knee, 1302

Knot, tying, with forceps, Grant's method, *622*, *623*
Knots, 606
clove-hitch, 606
double, 606
false, 606
friction, 606
granny, 606
reef, 607
sailor's, 607
square, *606*, 607
Staffordshire, 607
stay, *606*, **607**, 624
surgeon's, *606*
Tait's, 607
Knotted bandage, 522
Koch, 148
Koch's bacillus, 158
Kocher, 18, 597, 1296
Kocher's amputation of hip, *659*
forceps, 600
gastric clamp for gastrectomy, *1035*
hemostatic forceps, *84*
incision, 974
in breast cancer, *905*
method of reducing dislocation of articular processes of spine, 760
operation for cancer of tongue, 824
partial gastrectomy, 1038, *1050*
point, 699
reduction of dislocation of shoulder, 355
Kodami, 1134
Köhler, 241
Köhler's disease, 240
of second metatarsal, 241
metatarsophalangeal syndrome, 328
Kohn's paraganglia, 498
Koller, 533
Kolmer, 746
Kondoleon operation for elephantiasis, 422
König, 240
König's cannula, 843
Kraske's operation for carcinoma of rectum, 1220
Kraus, 491
Krause, 783
Krause-Wolfe method of skin-grafting. 617
Krömpecher, 471
Krönlein, 801
Krönlein's method of craniocerebral topography, 693
of partial gastrectomy, *1039*
Kulenkampff, 554, 577
Kummell's disease, *765*, 766
Kurtz, 223, 231
Kuschner, 99
Kussmaul, 392
Küttner, 783
Kyphosis, 767
of thoracic spine, 873

La Roque, 1198
La tabatière, 634
Labarraque's solution, 134
Labial artery, digital compression, 80
fistula, 784
Labor, deformation of skull during, 664
Laborde's method of artificial respiration, 501
Laborer's back, 381
Lacerated wounds, 36, **40**
treatment, 41
Laceration, cerebral, 707
of diaphragm, 874
of liver, 1122
of peripheral nerves, 430
Lacing liver, 1121
Lacrimal bone, fracture, 275
Lacrimatory gas, effects of, 71
Lacteal cysts, 896
Laennec's cirrhosis, 1126
Lahey, 621 867
Lahey and Jordan, 1008
Lahore sore, 178
Lambotta, 271
Lamina, spinal, fracture, 763
Laminectomy, 776, *777*, *778*, *780*, **781**, *782*
after-treatment, **781**
Lancets, 595
Lane, 269, 598
Lane's kink, **990**, 1068
needle, 602
operation for cleft-palate, **787**, *788*
plates, 270
Langdon's spinal manometer, *739*
Lange, 386
Langenbeck, 170
Langenbeck's operation for cleft-palate, 787, *788*
Lanz, 422
Laplace, 50, 1090
Larrey's amputation of hip, 659
of shoulder, 653
Larvæ of insects, invasion of tissues by, **58**, *59*
of tapeworms in breast, 896
Laryngeal cartilages, absence or hypoplasia, 833
dislocation, 837
chondritis, 839
dyspnea, 926
nerve, superior, injury, 852
lesions, 736
perichondritis, 839
stridor, 489
Laryngectomy, complete, 844
partial, 844
Laryngitis, 838
edematous, 838
syphilitic, 840
Laryngocele, 833
Laryngoscope, Jackson's, 835
Laryngoscopy, 835
Laryngotomy, 842
Larynx, 832
abscess, 839
artificial, 844
burns, 837
cancer, 841
cocain anesthesia, 557
concussion, 835
congenital anomalies, 832
fissure and fistula, 832
stenosis, 833
contusion, 835
dislocation, 837
foreign bodies in, 833
fracture, 836
inflammation, 838
occlusion, 837
scalds, 837
stricture, 837
traumatic injury, 835
tumors, 831
wounds, open, 838
Lasègue's sign in sciatica, 435
Latlame, 747
Laudable pus, 26
Law, Broders', 244
Colles', in syphilis, 163
Courvoisier's, 1149
in carcinoma of pancreas, 1156
Gunn's, in treatment of dislocations, 350
Profeta's, in syphilis, 163
Lawn-tennis arm, 381
Le Conte's interscapulothoracic amputation, 653
Le Forte's modification of Pirogoff's amputation of ankle, 656
Le Page, 649
Lead in treatment of cancer, 219
Leakage following gastro-enterostomy, 1022
Learmonth, 775
Leather-bottle stomach, 1030
in carcinoma, 1036
Lebsche, 951
Lee's agglutinin test in blood-transfusion, 91
Leeches, bite of, 61
Leg, amputation, 657. See also *Amputation of leg*.
racket incision, 646
Smith's elliptical, *646*
modified circular, *646*
racquet, *646*
artificial temporary, 649
Barbadoes, **187**, *421*, **461**
bow-, 1303
cochin, 461
elephant, 187
elephantiasis, **421**
Leg, flap amputation, *647*
milk-, **412**
rider's, 381
tennis, 1304
varicose veins, 194, *414*
X-, 1302
Legg's disease, 239, **240**, 1302
Lehmann, 509
Leiomyoma, 191
of testes, 1285
Leishmania tropica, 178
Leishmaniasis, 179
American, 179
aurinasal, 179
cutaneous, 178
dermal, 178
mucocutaneous, 179
Lembert's intestinal suture, *1085*, 1086
Lengthening tendo achillis, Anderson's method, *385*
Lenhartz's diet, modified, in peptic ulcer, 1008
stomach-clamp forceps for gastro-enterostomy, *1012*
Lennander's incision, 972
Lentigines, 801
Lentz-Downes cautery handle, *597*
transformer and rheostat, *596*
Leontiasis, 683
ossea, 229
osteitis deformans and, differentiation, 684
Lepra, 173
anæsthetica, 173, **174**
mutilans, 174
nervosa, 174
nodosa, 173, **174**
tuberculosa, 174
tuberosa, 174
Lepromes, 174
Leprosy, 173
of face, 797
Leptomeningioma, 775
Leptomeningitis, **687**, 773
Leptus autumnalis, 60
Leriche, 108, 644
Lespinasse, 1284
Lethargy, African, 62
Leukemia, roentgen rays in, 517
splenomyelogenous, 1162
Leukocidin, 141
Leukocytes, 25
Leukocytosis in acute appendicitis, 1100
in fractures, 261
Leukokeratosis, 209, **821**
Leukoma, 209
of tongue, 821
Leukonychia, 473
Leukopathia unguium, 473
Leukopenia, 1120
Leukoplakia buccalis, 209, **821**
Levi, 491
Levis, 404
Levis' splints, 532
Lewis, 910
Lexer, 345, 620, 621, 733
Lice, bites of, 60
dust-, 61
wood-, bites of, 60
Lifting face, 733, *791*
Ligament, cruciate, rupture, 375
round, hydrocele, 1282
varicocele, 414
Ligation, 84, **622**
in aneurysm, 407
intestinal, 1088
of abdominal aorta, 634
of anterior branch of middle meningeal artery, *628*
tibial artery, 638
of arteries, 622
at point of election, 624
of necessity, 624
blood-pressure and, 624
rules for, 86
of axillary artery, 632
of brachial artery, 633
of common iliac artery, 635
of dorsalis pedis artery, 639
of external carotid artery, 627
iliac artery, 636
maxillary artery, 630
of facial artery, 630
of femoral artery, 637

Ligation of gustatory artery, 630
of hypogastric artery, 635
of ileocolic vein, Braun's operation, 1124
of inferior gluteal artery, 636
thyroid artery, 630
of innominate artery, 625
of internal carotid artery, 629
iliac artery, 635
of lingual artery, 630
of occipital artery, 631
of peroneal artery, 640
of popliteal artery, 638
of posterior tibial artery, 639
of radial artery, 633
of right common carotid artery, 626
of sciatic artery, 636
of subclavian artery, 631
of superior gluteal artery, 636
thyroid artery, 629
of temporal artery, 630
of thyroid gland, 487
of ulnar artery, 633, **634**
of vertebral artery, 630
preliminary, 86
prophylactic, 86
Ligatures, 604
carrier, 603
chain, 605
double, 605
elastic, 596
Erichsen's, **85**, 605
lateral, 606
occluding, 606
soluble, absorbable, 606
suboccluding, 606
twine, 596
varieties, 84
Light, disinfection by, 132
Lightning figures, 67, **74**
stroke, 74
Ligneus phlegmon, 854
Lilienthal, 920, 933, 942
Lime, chlorid of, as disinfectant, 134
Linderman's method of blood-transfusion, 92
Line, Nélaton's, in fracture of neck of femur, 306
Truemmerfeld, 224
Linear fracture, 255
of skull, 671, *672*
Lingual artery, ligation, 630
dermoids, 220
Linguatula rhinaria, 60
serrata, 60
Liniment, soap, 140
soft, 140
Liniments, 140
Linimentum ammoniæ, 140
calcis, 140
camphoræ, 140
chloroformi, 140
saponis, 140
mollis, 140
terebinthinæ, 140
Linitis plastica, 1030
in carcinoma of stomach, 1036
Lion face, 229
Lip, adenoid carcinoma, 802
chancre, *796*
chronic induration, 789
double, 789
epithelioma, *802*, *803*
lower, mucous cysts, 797
lymphangioma, 801
strumous, 789
upper, adenomatous polyp, *203*
carbuncle, 466
new, formation of, *612*
Lipectomy of abdominal wall, *965*, *966*, 971
Lipiodol in roentgenography of lung, 923
injection into spinal canal, 747
Lipoma, 192
arborescens, 192, **341**
diffuse, 193
molle, 193
of abdominal wall, preperitoneal, 971
of chest, 884
of colon, *1080*
of face, 798
of lung, 936
of neck, 858
Lipoma of parotid, 829
of small intestine, 1079
pendulum of chest, 884
properitoneal, 192, **1202**
sacrococcygeal, congenital, 757
subperitoneal, femoral hernia and, differentiation, 1197
subsynovial, 192
treatment, 193
Lipotamponade, 941
Liquefaction cysts, 222
necrosis, 100
Liquor alumini acetatis for wet or moist dressing, 50
antisepticus, 137
alkalinus, 137
aromaticus alkalinus, 137
cresolis compound as disinfectant, 133
hydrogenii dioxidi as disinfectant, 136
iodi compositus, 133
puris, 26
Lisfranc's amputation of foot, 655
Listerine, 137
Listerism, 128
Liston, 645, 920
Liston's amputating knives, 595, *596*
bone-cutting forceps, *597*
straight splint, 531
Litholapaxy, 1253
indications, 1254
Keith's, 1254
Lithotomy, 1254
perineal, 1254
suprapubic, 1254
vaginal, 1254
Lithotrite, Bigelow's, *1254*
Lithotrity, 1253
Littré's hernia, 1167
Liver, 1119
abscess, 1122
amebic, 1122
drainage, 1123
multiple, 1123
operation for, 1123
pyemic, 1123
pyogenic, 1122
solitary, 1122
subphrenic abscess and, differentiation, 988
tropical, 1122
actinomycosis, 1126
angioma, 1128
congenital, 1128
anomalies, 1121
carcinoma, 1128
cirrhosis, 1126
hematemesis in, 1024
paracentesis abdominis in, 1126
saphenous peritoneal anastomosis for, 1127
Talma-Morrison operation, 1127
collateral circulation, 1126
congenital transposition, 1121
contusions, 1122
corset, 1121
cysts, 1128
echinococcus, 1124, *1125*
hydrated thrill in, 1125
deficiency, treatment, 1121
disease, acidosis in, 1120
treatment, 1121
alkalinosis in, 1120
treatment, 1121
carbohydrate test, 1120
cholecystography in, 1119
dye-elimination test, 1120
hemoclastic crisis of Widal in, 1120
icterus index, 1120
protein metabolism in, 1120
tests for, 1119
urobilin test, 1120
van den Bergh's test, 1120
dulness, obliterated, in pneumoperitoneum, 956
hobnail, 1126
in anesthesia, 538
lacerations, 1122
lacing, 1121
movable, 1121
operations, position for, *1138*
Riedel's lobe, 1121
rupture, 961
sarcoma, 1128
Liver structures subject to injury in gall-bladder operation, *1146*
sugar-ice, 995, 1127
tests, functional, 1119
traumatic injury, 1121
tumors, 1128
Livingston, 55
Lobar mastitis, 893
Lobe, Riedel's, 1121
Lobectomy in bronchiectasis, 933
Lobstein, 224
Lobstein's disease, 224
Lobster-claw hand, 1292
Localization, intestinal, *1053*, 1054
Locke's solution to stimulate arrested heart, 947
Lockjaw, 149, 806
Locomotor ataxia, peptic ulcer and, differentiation, 1017
Lodor-Cotton position in Colles' fracture, 295
Loewi, 479, 1154
Löffler and Shütz, 172
Lohr, 90
Long, 533
Longitudinal fracture, 256
sinus, thrombosis, 712
Loop motor amputation, 642
Loose bodies in joints, 332
Loosening of nails, 473
Lorain type of infantilism, *491*
Lordosis, 767
of thoracic spine, 873
Lorenz's operation for congenital dislocation of hip, 373
for ununited fracture of neck of femur, 308
Loreta's pylordiosis, 1047
Loving's pressure pneumothorax apparatus, *940*
Lowen, 575
Lowenthal, 858
Luckhardt, 551
Ludloff's sign in fracture of neck of femur, 306
Ludwig's angina, 144, **853**
Luer, 598
Lues, 161
Lugol's solution, 133
in exophthalmic goiter, 481
Lukens, 929
Lukens-Yankauer return-flow tube, 929
Lumbago, 382
Lumbar abscess, 769, 772
anesthesia, 561
anus, formation of, in rectal carcinoma, 1220
hernia, 1203
muscles, rigidity, 1222
neuralgia, 434
puncture in brain tumors, 721
vertebræ, abscess, 769, 772
Lumbosacral fibrositis, 382
vertebræ, abscess, 772
Lumpy jaw, 170
Lunar caustic, 136
Lunate bone, dislocation, anterior, 362
fracture, 299
Kienboch's disease, 299
Lund swathe, 529
Lung, 923
abscess, 928
artificial pneumothorax in, 929
operative drainage, 929
postural drainage, 929
pulmonary tuberculosis and, differentiation, 929
anomalies, 923
carcinoma, 936
secondary, 937
decortication, 921
diagnostic methods, 923
diseases, 930
echinococcus cysts, 935
edema, 927
enchondroma, 936
endothelioma, 936
expansion, methods for, after thoracostomy, 921
fibroma, 936
Freund's operation, 942
gangrene, 929
hemorrhage into, 927
hernia in wounds of chest, 879

Lung, hydatid cysts of, 935
injury, 874
lipoma, 936
lipotamponade, 941
lymphoma, 936
lymphosarcoma, 936
malignant disease, Roentgen diagnosis, 936
mapping, bronchoscopic, 923
massive collapse, 928
operations, 939
common, 940
embolism complicating, 934
for injuries, 926
positions for, *932*, *933*
rare or objectionable, 939
osteoma, 936
paste injections, embolism from, 934
prolapse, in wounds of chest, 879
Quincke's operation, 941
roentgenography, lipiodol in, 923
sarcoma, 936
tracheobronchoscopy, 923
tumors, 936
benign, 936
empyema and, differentiation, 915
malignant, 936
Roentgen diagnosis, 936
secondary, 937
treatment, 937
by radium, 937
Wilms' operation, 941
wounds, 926
operation for, 927
Lupus carcinoma, 208
elephantiasis, 424
exedens, 467
exfoliativus, 467
non-exedens, 467
of face, 795
non-ulcerative type, 795
syphilis and, differentiation, 796
ulcerative type, 795
verrucose type, 795
ulcerans, 467
vulgaris, 159, 467
Luschka's gland, 498
Lutz, nodules of, 343
Luxations, 346. See also *Dislocations*.
Lymph accumulation, 419
method of reaching blood, 419
scrotum, 187
Lymph-glands, carcinoma, 428
cyst, 419
diseases, 419
fistula, 419
inflammation, acute, 423
melanoma, 428
obstruction, 420
of neck, syphilis, 856
tuberculosis, 855
peripheral, inflammation, 422
sarcoma, 428
stasis, 420
traumatic injury, 419
tuberculosis, 159
tuberculous, 159, 424
tumors, primary, 427
secondary, 428
varicocele, 421
varix, 420, 421
wounds, 419
Lymph-nodes, enlarged, from axilla containing metastatic cancer, *209*
involvement, in cancer of breast, 899, 901
of neck, 853
Lymph-scrotum, 421
Lymph-stasis, 420
Lymph-varix, 420, 421
Lymph-vessels, diseases, 419. See also *Lymph-glands*.
Lymphadenie cutanee, 175
Lymphadenitis, acute, 423
of neck, 855
chronic, 424
mediastinal, 938
acute, 938
suppurative, 938
tuberculous, 938
mesenteric, tuberculous, 425
tuberculous, 424
cervical, 424
of neck, 855
Lymphadenoma, 197
cells, 425
general, 197
malignant, 425
Lymphadenopathy in acute appendicitis, 1100
Lymphadenovarix, 421
Lymphangiectasia congenita, 856
Lymphangiectasis, 420
congenital, 427
filarial, 421
Lymphangioma, 193, **197, 427**
cavernous, 197
of face, 800
of neck, 857
cystic, 197
of face, 800
cystoides, 856
of cheeks, 801
of chest, 885
of face, 800
of lips, 801
of neck, 801
of parotid, 829
of skin, 801
of tongue, 801
simplex, 197
telangiectatic, 197
of face, 800
Lymphangioplasty, Handley's, 420, 909
Lymphangiorrhaphy, Handley's, for ascites, 994
Lymphangitis, 422
syphilitic, 424
tuberculous, 424
Lymphatic changes in inflammation, 20
cyst, 427
drainage of stomach in relation to partial gastrectomy, 1042
infection of gall-bladder, 1136
obstruction, 420
system, 419
Lymphaticostomy, Costain's, for jejunal toxemia in peritonitis, 984
Lymphatics, 419. See also *Lymph-glands*.
Lymphedema, 419, 420
of arm, 420
Lymphoblastoma, 428
of stomach, 1035
Lymphoglandular tuberculous peritonitis, 991
Lymphoma, 197
malignant, 197, **425**, 428
of lung, 936
Lymphorrhagia, 419
Lymphosarcoma, 200, 427
of bronchus, 936
Lynn, 645
Lysol as disinfectant, 133
Lyssa, 153

MacDonald's solution, 133
MacLean, 1055
MacLean's test of renal function, 1226
MacLeod, 122
Macalister, 176
Macewen, 138, 260, 404, 877, 935
Macewen's chisel, modified, 235
method of compression of abdominal aorta, 80
operation for genu valgum, 1303
powder in abscess of brain, 711
Macrocheilia, 197, 427, 784, 801
Macrodactylism, 1289
Macroglossia, 197, 427, 801, 819
Macromelia, 427, 801
Macrosomatia, 498
Macrosomia, 498
Macrostomia, 784
Macrotia, 785
Maddren, 301
Madelung, 1291
Madelung's deformity of wrist, 1291
Madura foot, 175
mycosis, 175
Magenstrasse, 1006
Maggots, 59
Mahler's symptom of phlebitis, 413
Maier, 392
Main en griffe, 455
fourche, 1292
Maisonneuve, 148
Maisonneuve's urethrotomy for stricture, 1269
Makin's, 410
Makka's operation for exstrophy of bladder, 1249
Mal d'engasgo, 868
Malabar ulcer, 179
Malachite green, 137, 138
Malacia of semilunar bone, 240
Malar bone, fracture, 275
Malarial inoculation in syphilis, 166
parasite, 65
Malgaigne's dislocation, 361
fracture, 301
treatment of dislocation of scapula, 357
Maliasmus, 172
Malignant adenoma of thyroid gland, 184
disease of nails, 474
edema, bacillus of, 148
goiter, 476
lymphadenoma, 425
lymphoma, 197, **428**
pustule, 152
stricture of rectum, 1217
Mallein, 173
Malleolus of tibia, fracture, 322
Mallet-finger, **301**, 1296
Malleus humidus, 172
Malnutrition in inflammation, 20
Malum perforans, 463
Mammals, injuries and diseases received from, 55
Mammary gland, 888. See *Breast*.
region, acute lymphadenitis, 423
Mammillitis, 889
Mandible, actinomycosis, *811*
fracture, 276
hypoplasia, 805
lower, dislocation, 351
syphilis, 810
tuberculous periostitis, 810
Mangolte's method of skin-grafting, 615
Mania à potu, 120
postoperative, 589
Mann, 1119, 1130, 1134
Manometer, spinal, *739*
Langdon's, *739*
Manus valga, 1291
Many-tailed bandage, 528
Marble bones, 225, **226**
Marginal ulcer, 1019
Marginate glossitis, 821
Margzloff, 1053
Marjolin, 213
Marjolin's ulcer, 206, 209, 213
Marsden's paste in cancer, 216
Marsupialization in pancreatic cysts, *1154*, 1155
Martin, 1284
Martin's bandage, 530
fistula director, *1210*
knife, *1211*
rectal speculum, *1210*
Mason, 275
Massage, 516
in non-union of fractures, 274
of heart, 502, **948**
Babcock's digital method, **948**
subdiaphragmatic, 948
transdiaphragmatic, 948
transthoracic, 948
Massive collapse of lung, 928
necrosis, 100
Mast-cells, 26
Mastitis, acute parenchymatous, 891
suppurative, 891
adolescentum, 890
carcinosa, 903
chronic, 893
cystic, 896
diffused lobular, 893
interstitial, cysts from, 896
cystic, 893
interstitial, 893
involution, 893
lobar, 893
neonatorum, 890
puerperalis, 891
Mastodynia, 434
Matas, 277, 399, 878

Matas' operation for aneurysm, *405*, *406*, 407
test for impending gangrene, 94
Mattress-sutures, *604*
Maunsell's incision for resection of intussusceptum, *1063*
operation for intussusception, 1094
Maury's twine-ligature method, 596
Maxilla, fracture, 275, 276
Maxillary artery, external, digital compression, 80
ligation of, 630
Maxwell-Ruth treatment of fracture of neck of femur, 307
Maydl's jejunostomy, 1048, **1089**
operation for exstrophy of bladder, 1249
Mayo, 488, 1013, 1053, 1160, 1161, 1162
Mayo's dissecting scissors, *27*, *596*
line for division of stomach in partial gastrectomy, *1041*
operation for hallux valgus, 1311
for umbilical hernia, 1199, *1200*
Mayo-Hegar needle-holder, *606*
Mayo-Robson, 1090, 1150
Mayo-Robson's incision, 974
jejunostomy, 1048
McArthur, 619
McArthur's incision, appendiceal, 972
gall-bladder, 974
McBurney's incision, 972
for appendectomy, *1110*, 1112
point, 954
in acute appendicitis, 1098
McCoy and Chapin, 156
McFarland, 56, 829
McGraw, 1045
McGraw's elastic ligature method, 596
McKee-McCready bite-block, *925*
McKesson, 537
McKesson's gas machine, 544
rule in shock, 115
McKibben, 512
McLoed, 169
McMartin, 177
Meatotome, 595
Meatus urinarius, atresia, 1277
stenosis, 1277
stricture, 1277
Mechanical disinfection, 132
Meckel's diverticulitis, 1055
diverticulum, 957, **1055**
inflammation of, 1055
Median nerve, injuries, 451
rerouting, Babcock's operation, *452*
Mediastinal emphysema, acute, 938
flutter, 877
lymphadenitis, 938
acute, 938
suppurative, 938
tuberculous, 938
Mediastinitis, acute, 937
posterior mediastinotomy in, 938
Mediastinopericarditis, indurative, 938
Mediastinotomy, posterior, in acute mediastinitis, 938
Mediastinum, dermoid cyst, 938
inflammation, 937
surgical diseases, 937
tumors, 939
Medulla, injuries and pressure, effects, 693
spinalis. See *Spinal cord*.
Medullary anesthesia, 561
carcinoma, 199, 207
of breast, 899, **903**
of rectum, 1218
of stomach, 1037
osteomyelitis, 231
paralysis, 703
Megacolon, 1055
Melanoblastoma of nail-bed, 474
Melanocarcinoma, 200, 210
Melanoglossia, 821
Melanoma, 200
of lymph-nodes, 428
of skin, 470
Melanosarcoma, 200
fungating, of eye, *200*
Melanotic carcinoma, 207
epithelioma, 470
sarcoma, 200, 470
of chest, 885
whitlow, 474
Meleney, 466
Melon-seed bodies in bursæ, 387
in joints, 332
Meltzer, 502, 1134
Meltzer and Auer, 545, 878
Membrane, Jackson's, 990, 1068
pyogenic, 27
Membranous replacement for defects of skull, 686
Mencière's mixture, 139
Ménière's disease, 734
Meningeal artery, middle, anterior branch, ligation, *628*
hemorrhage from, 706
cry, 688
Meninges, 687
inflammation, 687
spinal, inflammation, 773
Meningioma, *713*, 775
Meningism, **688**, 773
Meningitis, 687
alcoholic serous, 121
basilar, 688
in children, Haynes' operations, 689
cerebrospinal, 688, 773
chronic, 689
diagnosis, 688
Diplococcus intracellularis, 688
Gradenigo's syndrome in, 688
pneumococcic, 688
purulent, 774
Quincke's serous, 697
septic, treatment, 689
serous, 774
spinal, 773
Staphylococcus albus, 688
aureus, 688
streptococcic, 688
symptoms, 688
syphilitic, 689
treatment, 689
tuberculous, 689
Meningocele, 670, 750
diagnosis, 752
prognosis, 754
sacrococcygeal, 756
Meningomyelitis, tumors of spine and, differentiation, 779
Meniscus, medial, of knee, dislocation, 375
Mental changes complicating skull injuries, 708
Mephitic gangrene, primary, 148
Mercurial periostitis of jaw, 809
Mercuric ammonium chlorid as antiseptic, 135
chlorid as disinfectant, 134
as wet or moist dressing for wounds, 50
iodid as antiseptic, 135
oxycyanid as antiseptic, 135
Mercurochrome in blood disinfection, 127
Mercurophen as antiseptic, 135
Mercury in syphilis, 165
solutions as wet or moist dressing for wounds, 50
Mercyism, 1033
Mesarteritis, syphilitic, 392
Mesenchyme, hereditary hypoplasia, 224, 225
Mesenteric lymphadenitis, tuberculous, 425
thrombosis, 95
Mesentery, tactile sensation in, 954
Mesoblastic odontoma, 205
Mesocephalic skull, 669
Mesocolic adhesion, 990
Mestrezat, 509
Metabolic rate in exophthalmic goiter, 481
Metabolism, protein, in hepatic disease, 1120
Metacarpal bones, dislocations, 364
first, base of, fracture, 299
saws, 598
shafts, fracture, 300
Metacarpophalangeal joint, dislocation, 364
Metal clips, Michel, 604, *605*
Metals, antiseptic properties, 134
Metastasis of tumors, 182
to bone from cancer of breast, 901
Metastasis to internal organs from cancer of breast, 903
Metastatic abscess, 27
Metatarsal epiphysitis, 241
fracture, 327
base of fifth, 328
head, Freiberg's infraction, 328
infraction, 241
neuralgia, 389
second, Köhler's disease, 241
Metatarsalgia, 389, 434, **1310**
anterior, 1310
Metatarsophalangeal amputation of foot, 653
osteochondritis, juvenile deforming, 241, 328
syndrome, Köhler's, 328
Metatarsus, second, head of, epiphysitis, 240
Meteorism, 1053
in intestinal obstruction, 1059
Methyl aldehyd as disinfectant, 136
Metritis, gonorrheal, treatment, 1267
Meyer, 212, 503
Mice, joint-, 332
Michel, 462
Michel's metal clips, 604, *605*
application, for cutaneous closure, *605*
Microbrachius, 1289
Micrognathia, 785
Micromastia, 888
Micromazia, 888
Micromelus, 1289
Micropus, 1289
Microstomia, 784
Microtia, 785
Micturition, reflex, 741
Midcolic artery, *1041*
Midgastric resection of stomach, 1052
Midgut, 1053
Midpalmar space, abscess, 1299
Midphalangeal disarticulation, 650
Midtarsal amputation of foot, 655
dislocation, 380
Mikulicz, 878, 1045
Mikulicz's disease, 828
drains, 52
in peritonitis, 983
enterectomy, 1092
kentrotribe, 1093
line for division of stomach in partial gastrectomy, *1041*
method of partial gastrectomy, *1038*
operation, 1046
Mild silver-protein, 136
Miles, 679
Miliary actinomycosis of intestines, 1078
aneurysm, 395
carcinosis, acute, 208
sarcosis, 198
tuberculosis, 159, **935**
of bone, 236
of kidney, 1236
Milium, 220
Milk cysts, 896
pathologic, 100
Milk-and-molasses enema, 504
Milk-leg, 99, 412
Milk-line, 888
Miner's anemia, 62
elbow, 390
Mitchell, 56, 106
Mixed tumors, 220
of parotid, 829
of testes, 1286
Mobile heart, 943
Möbius' sign in exophthalmic goiter, 480
Moeller, 224
Moeller-Barlow disease, 224
Moist dressing for wounds, 49
principle, *48*
solutions used, 50
gangrene, 101
of penis, 1280
Molar necrosis, 100
Molded splints, 531
removable, 531
Molecular necrosis, 100
Moles, 193, 204, 799
hydatidiform, 188
of chest, 884

Mollities ossium, 226
Molluscum contagiosum, 468
fibrosum, 459
of neck, 858
of scalp, 669
Momburg's tourniquet, 82
Monks, 1053, 1054
Monobrachius, 1288
Monochloromethyl chloroformate, effects of, 71
Monorchidism, 1281
Monsel's solution, 83
Monsters, twin, 873
Moore, 404
Moore-Corradi operation for aneurysm, 404
Moot's index for operability, 536, **537**
Morbus coxa, 310
coxæ senilis, 340
coxarius, test for fixation of hip-joint in, *336*
maculosus of Werlhof, 1162
Moriarty, 277
Morning drop, 1261
Morphea-like epithelioma, 472
Morris, 19, 621
Morris' points, 954
Morrison, 995
Morrison's bipp, 993
incision, 974
modification of Talma's operation for cirrhosis of liver, 1127
Morton, 389, 533
Morton's disease, 389
fluid, **133**, 671
painful affection of foot, 434
toe, 1310
Morve, 172
Moschowitz's operation for femoral hernia, 1198
for prolapse of rectum, 1215
Mosetig-Moorhof, 48
treatment of osteomyelitis, 235
Moskowicz's test for impending gangrene, 94
Mother yaw, 167
Mother's mark, **194**, 799
Motor fibers, transplantation, 783
insufficiency of stomach, 1025
nerves, physiology, 429
neuroses of stomach, 1032
tests to determine conductivity of peripheral nerves, 437
Mountain sickness, 72
Mouth, 818
atresia, 784
congenital malformations, 784
imperforate, 784
operations on, preoperative treatment, 585
phimosis, 784
trench, 818
ulcers, 818
Mouth-gag, Denhardt's, *543*
Movable heart, 943
kidney, 1227
cholecystitis and, differentiation, 1141
liver, 1121
periosteal osteoma, 242
spleen, 1158
Rydygier's operation, 1158
Moxa, 516
Moynihan, 1007, 1009, 1013, 1045, 1052, 1132
Moynihan's antiseptic cream, 139
Mozambique sore, 179
Mucocele of appendix, 1117, *1118*
Mucocutaneous leishmaniasis, 179
Mucopurulent catarrh, 21
inflammation, 21
Mucopus, 26
Mucous catarrh, 21
cysts of intestine, 1076
of lower lip, 797
of tongue, 820
patch, 161
polyps, 188
of rectum, 1218
Muir, 979
Mulespinner's cancer, 1287
Multangular bone, greater, dislocation, 363
Multilocular cyst of ovary, 203
Multilocular dental cyst, 814
Multiple abscesses of liver, 1123
breasts, 888
hemorrhagic sarcoma, 470
nipples, 888
sarcoid of Boeck, 469
of skin, 175
Mummification, 101
Mumps, 828
Murphy, 260, 333, 344, 877, 878, 940, 1090, 1098, 1111
Murphy's button in stomach, 1003
drip, 504
fist-percussion of kidney, 1223
formalin glycerin, 136
reamer and mill, *344*
Murray, 1181
Muscles, abscess, 382
atrophy, 381
congenital anomalies, 381
contractures, 383
contusion, 381
cysts, 384
desmoid tumor, 384
diseases, 381
facial, spasm, 733
fibrosarcoma, 384
gas-bacillus infection 382
hernia, 381
inflammation, 382
kneading, 516
lumbar, rigidity, 1222
operations on, 386
ossification, 242
rupture, 381
sarcoma, 384
spastic, nerves supplying, alcoholic injection, 783
sternomastoid, gumma of, 856
strain, 381
striped, regeneration of, 26
stripping, 386
thenar, paralysis of, treatment, 387
transplantation for facial paralysis, 733
tumors, 384
unstriped, regeneration of, 26
wounds, open, 382
Muscular contractures, 383
rheumatism, 382
Musculocutaneous nerve, injuries, 449
Musculospiral nerve, injuries, 449
palsy in anesthesia, 540
Mushroom catheter, *1258*
Mustard gas, effects of, 71
plaster as counterirritant, 516
Mycetoma, 175
dark or melanoid, 175
of bones, 239
pale, 175
Mycobacterium tuberculosis, 158
Mycosis fungoides, 175
Madura, 175
Mycotic aneurysm, 398
Myelitis, chronic, spinal tumors and, differentiation, 779
Myelocele, *747*, 748
dorsal, *752*
Myelocystocele, 748
Myeloid tumor, 252
Myeloma, 251, **252**
differential diagnosis, 254
of bursæ, 390
of skull, 686
predisposing to fractures, 259
Myelomeningocele, 748
Myeloplasty, 807
Myiasis, 59
Myogenic torticollis, 848
Myoma, 191
levicellulare, 191
of bladder, 1257
of small intestine, 1079
of stomach, 1033
striocellulare, 191
Myositis, 382
ischemic, 1294
ossificans, 190, **383**
after dislocation of elbow, 359
progressiva, 383
ossifying, 383
Myxangiosarcoma tubulare, 201
Myxedema, postadolescent, 478
postoperative, 478
Myxedema, skin in, 461
Myxoma, 188
gelatinosum, 188
intracanalicular, 188
of breast, 897
medullare, 188
molle, 188
of parotid, 829
Myxoneuroma of chest, 884
Myxosarcoma of kidney, 1241
of umbilicus, congenital telangiectatic, 959

Nævus pilosi of chest, 884
Naga sore, 179
Nail horns, 205
Nail-bed, melanoblastoma, 474
tumors, 474
Nailing of fractures, 270
Nails, anatomy, 473
atrophy, 473
brittle, 473
degeneration, 473
diseases, 473
hyperplasia, 473
inflammation, 474
ingrowing, 473
loosening, 473
malignant disease, 474
overgrowth, 473
shedding, 473
softening, 473
splitting, 473
spoon-, 473
turtle-shell, 429
white spots, 473
Narcotic coma, 118
delirium, 120
Nasal bones, fractures, 274
clefts, 785
inhaler, *549*
saws, 598
Nausea in appendicitis, 1098
in pancreatic disease, 1150
Navel, hemorrhage from, 958
Navicular bone dislocation, 362
double, 1291
fracture, 298
tarsal scaphoid, Köhler's disease, 240
Neck, 845
actinomycosis, *854*, 855
acute lymphadenitis, **423**, 855
angioma simplex, 857
blastomycetes, 856
blood-cysts, 857
branchial cyst, *221*
cancer, 858
cavernous angioma, 857
lymphangioma, 857
cellulitis, 854
congenital anomalies, 845
serous cysts, 856
cystic hygroma, congenital, *845*
Derbyshire, 476
dermoids, 856
diffuse fibromatosis, 858
echinococcus cysts, 857
elephantiasis, 858
enchondroma, 858
fibroma, 858
molluscum, 858
fistula, 845
glands, tuberculous disease, 424
gunshot wounds, 850
hemangioma, 857
hydrocele, 427
lipoma, 858
lymphangioma, 801
lymph-glands, syphilis of, 856
tuberculosis of, 855
lymph-nodes, 853
nerve injuries, 850
neurofibroma, 858
neuroma, 858
osteoma, 858
potato-like tumor, 859
radium paresthesia, 850
Roentgen-ray paresthesia, 850
sarcoma, 858
sebaceous cysts, 857
sinus, lateral, 845
median, 845
stiff, acute, 382

Neck, teratoma, 845
tuberculous lymphadenitis, 855
tumors, 857
von Recklinghausen's, 858
wry-, 848
Necrosis, 22, **100**
arsenical, of jaws, 809
cheesy, 100
coagulation, 100
colliquation, 100
en masse, 100
exanthematous, of jaw, 810
liquefaction, 100
local, from cold, 72
massive, 100
molar, 100
molecular, 100
phosphorus, of jaw, 809
quiet, 230, **236**
senile, 230
varieties, 100
without suppuration, 236
Necrotizing infection, 125
Needle-holder, Babcock's, *606*
for appendectomy, *1108*
Mayo-Hegar, *606*
Needles, 602
aneurysm, 603
Carrel's, 602
cutting-edge, 603
Hagedorn, *602*
in stomach, 1003
Lane's, 602
pedicle, 603
Reverdin's, 603
round-pointed, 602
transfixion, 603
Needling kidney, 1242
Negri, 154
bodies, 154
Neisser, 147, 173
Neisserian urethritis, 1260
Nélaton's line in fracture of neck of femur, *305*, 306
Nematodes, 61
Neoplasms, 181. See also *Tumors*.
Neoplastic fractures, 258
Neoplasty, 619
Nephrectomy, 1242
for renal calculus, 1231
Nephritis, purulent, 1234
Nephrolithiasis, 1228
latent, 1229
tendency to recur, *1232*
Nephrolithotomy, **1231**, 1242
Nephropexy, Edebohls', 1242
Nephroptosis, 1227
Nephrostomy, 1242
Nephrotomy, 1242
Nerve, abducens, lesions, 730
accessory, injury, 852
lesions, 736
acoustic, lesions, 734
anterior, crural, injuries, 456
auditory, lesions, 734
auricular, great, paresthesia of, 851
auriculotemporal, lesions, 730
axillary, injuries, 449
circumflex, injuries, 449
clamp, Babcock's, *440*
cochlear, lesions, 734
common peroneal, injuries, 458
cranial, eighth, lesions, 734
seventh, lesions, 731
sixth, lesions, 730
external popliteal, injuries, 458
respiratory, of Bell, paralysis, 448
facial, anastomosis, 732
lesions, 731
femoral, injuries, 456
genitofemoral, 953
glossopharyngeal, lesions, 735
neuralgia, 735
hypoglossal, lesions, 737
ileohypogastric, 953
ilio-inguinal, 953
injuries of neck, 850
internal popliteal, injuries, 459
laryngeal, superior, injury of, 852
lesions, 736
lateral femoral cutaneous, injuries, 457
long thoracic injuries, 448
median, injuries, 451
Nerve, median, rerouting, Babcock's operation, *452*
musculocutaneous, injuries, 449
musculospiral, injuries, 449
obturator, injuries, 456
oculomotor, lesions, 726
olfactory, lesions, 725
optic, lesions, 725
patheticus, lesions, 726
phrenic, division of, 942
lesions, 737
pneumogastric, lesions, 735
radial, injuries, 449
paralysis, treatment, 451
recurrent, injury, 852
lesions, 736
regeneration of, 26
sciatic, injuries, 457
neuralgia, 435
stretching in sciatica, 436
superior gluteal, injuries, 456
suprascapular, injuries, 449
sympathetic, cervical, lesions, 737
symptoms complicating skull injuries, 708
tibial, injuries, 459
trifacial, lesions, 726
trigeminal, lesions, 726
trochlear, lesions, 726
ulnar, injuries, 455
rerouting, to front of elbow, *442*
vagus, lesions, 735
vestibular, lesions, 734
Nerve-grafting for gaps in peripheral nerves, 443
Nerve-roots, spinal, localization, 739
Nerve-stretching for gaps in peripheral nerves, 443
Nerves, abdominal, relation of incisions to, 954
cranial, lesions, 725. See also *Cranial nerves*.
motor, physiology, 429
of abdominal wall, 953
parietal, of abdominal wall, 954
peripheral, 429. See also *Peripheral nerves*.
sensory, physiology, 429
special, lesions of, 446
spinal, of abdominal wall, 953
supplying spastic muscles, alcoholic injection, 783
sympathetic, resection of, 783
Nervous theory of tumors, 184
Neuhof, 1124
Neuralgia, 433
brachial, 434
cervical occipital, 433
crural, 434
epileptiform, 727
facial, 727
in gunshot wounds of face, 792
intercostal, 434, 883
lumbar, 434
major, 727
metatarsal, 389
minor, trigeminal neuralgia and, differentiation, 727
of coccyx, 304
of glossopharyngeal nerve, 735
of sciatic nerve, 435
trigeminal, 727
Neuralgic joints, 342
Neurasthenia, spinal, traumatic, 759
Neurectasis for gaps in peripheral nerves, 443
in sciatica, 436
Neuritis, optic, 726
in tumors of brain, 715
traumatic, 432
Neuroblastoma of adrenals, 499
Neurofibroma of face, 798
of neck, 858
Neurofibromatosis, generalized, 459
Neurogenic fracture, 257
theory of gastric ulcer, 1007
torticollis, 848
Neuroglioma ganglionare, 191
Neurolipoma, 192
Neurolysis, 437
Neuroma, **190**, 459
amputation, 190, 431, **644**
cirsoid, 190
elephantiasis, 459
Neuroma, false, 187, 190
fibrillar, 190
ganglionar, 190
of neck, 858
plexiform, 190, 459
of scalp, 669
traumatic, 431
true, 190
Neuromimetic joints, 342
Neurorrhaphy, 439
technic, *438*, 440
Neuroses, functional, trigeminal neuralgia and, differentiation, 727
of stomach, 1032
motor, 1032
secretory, 1033
sensory, 1033
Neurotoxin of snake venom, 57
Nevolipoma, 194
Nevus, 193
angiectodes, 194, 799
araneus, 194, 799
capillary, 469
flammeus, 194, **469**, 800
lipomatodes, 469
lymphaticus, 197, 427, 801
of face, 798
pigmented, 801
vasculosus, 194, 799
vinosus, 194, 800
Newborn, intracranial hemorrhage, 707
New-growths, 181. See also *Tumors*.
Nichols, 232
Nicoladoni, 620, 1045
Night cries in tuberculous arthritis, 336
Ninth cranial nerve, lesions, 735
Nipples, absence, 888
inflammation, 889
multiple, 888
Paget's disease, **894**, *895*
squamous-cell epithelioma, 904
Nitrous oxid anesthesia, 548
action, 548
administration, 549
contraindications, 549
dangers, 549
physiology, 548
oxid-oxygen anesthesia, 548
Noble, 1106
Noble's position for examining kidney 1222
Noci, 113
Nocturnal incontinence of urine, 1247
Nodes, Heberden's, in osteo-arthritis, 341
Parrot's, 683
Nodular leprosy, 173, 174
Nodules, apple-jelly, 796
crab-apple-jelly, 30
juxta-articular, 343
of Lutz, 343
Noguchi, 161
Noli-me-tangere, 210
Noma, **110**, 144
pudendi, 110
Nonne-Apelt test of cerebrospinal fluid, 746
Nonne's syndrome, 746
test of cerebrospinal fluid, 746
Northrup, 878
Nose, big, 176
Burgundy, 798
cocain anesthesia, 557
congenital malformations, 785
dog, 176
hemorrhage from, treatment, 89
potato, 463, 798
saddle-, correction, *797*
from submucous resection, *791*
Noviform, 139
Novocain, local anesthesia by, 558
Nuck, canal of, hydrocele, 1282
Nunnely, 551
Nurses in operating-room, 582
Nutrition, intravenous, 511
Nycturia, 1225

Oblique bandage, 521
fracture, 256
Obliterative aneurysmorrhaphy, 407
appendicitis, 1096
endarteritis, 391, 393
injections in varicose veins, 415

Obstipation in acute appendicitis, 1100
in intestinal obstruction, 1059
Obstructive jaundice, 1128, *1129*
clinical, symptoms, 1130
Obturator canal, *1165*
dislocation of hip, 369
hernia, 1203
nerve, injuries, 456
Occipital artery, ligation, 631
lobe of brain, 690
neuralgia, cervical, 433
Occupation bursitis, 387
Ochsner, 981, 983
Ochsner's forceps, 600
treatment for appendicitis, 1101
for peritonitis, 982
O'Connor, 512
Ocular torticollis, 848
Oculomotor nerve, lesions, 726
Odontoma, 205
composite, 205
compound follicular, 205
epiblastic, 205
epithelial, 205, 814
fibrous, 205
follicular, 205, 814
hard, 205
mesoblastic, 205
radicular, 205
O'Dwyer and Fell, 878
O'Farrel, 466
Ogsten's operation for genu valgum, 1303
O'Hara's forceps, 1092
Oïdiomycosis, 176
Oil encephalography, 694
iodized, injection, into spinal canal, 747
Ointment, Kentish's, 140
Olecranon bursa, inflammation, 390
epiphysitis, 240
process, fracture, 290
Olefiant gas anesthesia, 551
Olfactory nerve, lesions, 725
Oligemia, acute, 113
Oliver's sign in aneurysm, 400
Ollier-Thiersch method of skin-grafting, 617
Omphalocele, 1198
Onion-layer appearance in Ewing's sarcoma, 251, 254
Onychauxis, 473
Onychexallaxis, 473
Onychia, 474
maligna, 474
parasitica, 474
simplex, 474
tuberculous, 474
Onychitis, 474
Onychoclasis, 473
Onychocryptosis, 473
Onychogryposis, 473
Onycholysis, 473
Onychoma, 474
Onychomadesis, 473
Onychomalacia, 473
Onychomycosis, 474
Onychoptosis, 473
Onychorrhexis, 473
Onychotrophy, 473
Onychotropia, 473
Open fracture, 257
Operability, energy index, 537
Moot's index, 536, 537
Operating room, resuscitation in, 583
suit, Babcock's *581*
table, position on, 584
Operating-room, 583
assistants, 582
nurses, 582
personnel, 582
staff, 580
technic, 580
Operations, 580
abdominal, exploratory, 956
for cholecystitis, 1143
for closed visceral injuries, 962
in private homes, 583
instruments used, 595
on heart, technic, 947
on heart-valves, 946
on intestines, 1085
on lung, 939
for injury, 926
Operations on mouth, preoperative treatment, *585*
on stomach, 1045
study of patient, 584
thoracic, 918
Operative surgery, 595
Ophthalmia neonatorum, Credé's method of preventing, 136, 148
Opiates in appendicitis, 1116
Opisthogenia, 785
Opisthotonos in nitrous oxid anesthesia, 548
Opium poisoning, cerebral compression and, differentiation, 703
Opsonins, 26
Optic atrophy in tumors of brain, 715
nerve, lesions, 725
neuritis, 726
in tumors of brain, 715
Optochin in blood disinfection, 127
Oral screw for jaws, *807*
Orbit, exostoses, 684
Orbital phlegmon, 793
Orchitis, 1284
gummatous, 1285
Oré, 553
Organic hour-glass in gastric ulcer, 1007
stricture of rectum, 1216
Organs, transplantation, 621
without vascular anastomosis, 621
Oriental sore, 178
Orr, Whipple, and Haden, 1058
Orthocephalic skull, 669
Orthoform, local anesthesia by, 561
Orthotonic stomach, *1025*
Os calcis, endemic enlargement, 1304
epiphysitis, 240
fracture, 326
secondary, 1304
stirrup, 269
capitatum, head of, dislocation, 363
epipyramis, 1291
incisivum, protruding, treatment, 789
magnum, dislocation, 363
fracture, 299
paratrapezium, 1291
peroneale, supernumerary, 1304
tibiale externum, supernumerary, 1304
triangularis, 1291
trigonum, supernumerary, 1304
ulnare externum, 1291
vesalii, supernumerary, 1304
versalium, 1291
Osgood, 240, 301
Osgood-Schlatter disease, 239, 240, 321
Osler's disease, 1161
Osmotherapy, intravenous, 512
Osseous tuberculosis of face, 795
Ossification in fractures, 260
incomplete, of skull, 665
of muscles, 242
of tendons, 242
Ossifying myositis, 383
periostitis, 190
Osteitis, 230
blastomycetic, 239
chronic non-suppurative, 236
deformans, 227
leontiasis and, differentiation, 684
treatment, 228
fibrosa, 228
cystica, *221*, 228
spinal, 766
suppurative, of ribs and sternum, 882
tuberculous, of jaw, 810
typhoid, 235
Osteo-arthritis, 340
gummatous, 339
of spine, 340
tumors of spine and, differentiation, 779
Osteo-arthropathy, hypertrophic pulmonary, 190
Osteoblastoma, 245
Osteoblasts, 25
Osteochondritis, 239
coxæ, 1302
deformans coxæ juvenilis, 1302
juvenilis coxæ, 239, 240
dissecans, 240
gummatous, 339
metatarsophalangeal, juvenile deforming, 241, 328
Osteoclasis, 1303
Osteocopic pain, 230
in aneurysm, 400
Osteogenesis imperfecta, 224
fetal, 225
Osteogenic sarcoma, 245
diagnosis, 248
differential diagnosis, 253
etiology, 247
of bones of feet, 246
of femur, 246
of fibula, 246
of humerus, 246
of jaw, 246
of pelvis, 246
of radius, 246
of shoulder-girdle, 246
of skull, 246
of tibia, 246
of ulna, 246
of vertebræ, 246
prognosis, 248
sun-rays appearance, 248, 253
symptoms, 247
treatment, 249
Osteoid sarcoma, 201
Osteoma, 189, 242
cancellous, 242
compact, 242
disconnected, 189, 242
durum, 189, 242
eburneum, 189, 242
of upper jaw, 816
heterologous, 189, 242
homologous, 189, 242
ivory, 242
medullare, 189, 242
movable periosteal, 242
of lung, 936
of neck, 858
of skull, 684
parosteal, 189, 242
periosteal, 189
related overgrowth, 190
spongiosum, 189, 242
treatment, 190
Osteomalacia, 226
fatty, 335
of skull, 683
predisposing to fractures, 258
Osteomyelitis, acute, 230
septic, traumatic, 235
medullary, 231
of jaw, 807, 808
of ribs and sternum, 882
of skull, 681
phosphorus, of jaw, 809
staphylococcus, *232*
tuberculous, 237
typhoid, 235
Osteoperiostitis, chronic, 236
Osteophyte, 189, 241
of skull, 684
Osteoplastic amputation, 642
craniotomy, *716*, *717*
reconstruction of bladder for exstrophy, 1250
Osteoporosis, 225
from disuse or trophic cause, 226
senile, 226
Osteopsathyrosis, 224
acquired, 226
congenita, 224, 225
with blue sclera, 224
with white sclera, 224
Osteosarcoma of chest, 885
of femur, 246, *248*
of humerus, *244*
of left ischium, *247*
of skull, 686
Osteosclerosis, diffuse, 237
frag lis generalisata, 225
Osteosynthesis, after-treatment, 345
Osteotomes, 600
Osteotomy, 344
subtrochanteric, for congenital dislocation of hip, 373
Otitis media, brain abscess and, 709
Oudin current, 518
Ovarian dermoids, 220
Ovary, cysts, tuberculous peritonitis and, differentiation, 992
multilocular cyst, 203
transplantation, 621

Overgrowth of bone, 227
of nails, 473
Oxymethylene as disinfectant, 136
Oxyuris vermicularis, 62
in appendix, 1097
infection of rectum, 1207

Pachyderma, 187, 461
Pachydermatocele of scalp, 669
Pachymeningitis externa, 687, 773
hemorrhagic, external, 706
internal, 687
interna, 773
Pagenstecher, 1086
Paget, 227, 236, 684, 894, 1248
Paget's disease, 685
of bone, 190, 227
of breast, 209
of nipple, 894, *895*
of skull, 684
recurrent fibroid, 200, 384
Pain as symptom of inflammation, 22
in aneurysm, 400
in dislocations, 348
in fractures, 261
in osteogenic sarcoma, 247
in tuberculous arthritis, 335, 336
in tumors of spine, 776
postoperative treatment, 590
osteocopic, 230
sensation, 429
tactile, abdominal, 954
Painful heel, 387, 435, 1312
urination, 1224
Palate, cleft-, 784, 787
hard, defects in, 789
Palatine abscess, 807
Palm, foreign bodies in, 1297
Palmar abscess, 1298
cellulitis, 1298
Palpation of esophagus, 861
of kidney, 1222
Palsy. See *Paralysis.*
Panarthritis, 329
Pancoast, 17
Pancreas, 1150
abscess, 1152
adenoma, 1155
calculi, 1153
carcinoma, 1155
cystadenocarcinoma, 1153
cystadenoma, 1153
cystic disease, 1153
cysts, 1153
extirpation of, 1155
false, 1151
hydatid, 1153
marsupialization in, *1154*, 1155
parasitic, 1153
proliferative, 1153
retention, 1153
traumatic, 1151
treatment, 1155
Wohlgemuth's test, 1154
disease of, Cammidge reaction in, 1151
general symptoms, 1150
inflammation, 1151
pseudocysts, 1153
sarcoma, 1155
traumatic injury, 1151
tumors, 1155
Pancreatic calculi, 1153
cysts, 1153
disease, Cammidge reaction in, 1151
general symptoms, 1150
ranula, 1153
Pancreatitis, acute, 1151
cholecystitis and, differentiation, 1141, 1152
operation, 1152
chronic, 1152
hemorrhagic, acute, perforated peptic ulcer and, differentiation, 1011
interacinar, 1153
interlobar, 1153
suppurative, 1152
Pandy's test of cerebrospinal fluid, 746
Pannus, synovial, 335
Papillary cholecystitis, 1142
Papilliferous cysts, 204
Papilloma, 204
hard, 204
Papilloma of bladder, 1257
of rectum, 1218
of renal pelvis, 1242
soft, 204
Papillomatous fibroma, 187
Paquelin cautery, 597
Para-amino-benzoyl-gamma-dinormal-butyl-amino-propanol sulphate, local anesthesia by, 557
Paracentesis abdominis for ascites, 994
in cirrhosis of liver, 1126
pericardii, 947
thoracis, 918
Paraffin cancer, 206
Paraffinoma, 461
Paraganglia, Kohn's, 498
Paralysis, abducens, after spinal anesthesia, 574
abduction, of thumb, treatment, 387
abductor, bilateral, 840
Bell's, 731
birth-, brachial, 447
brachial, in anesthesia, 540
crutch, 450
drunkard's, 450
extensor, of fingers, Stöffel's operation, 387
of wrist, Jones' operation, 386
Stiles' modification, 386
Stöffel's operation, 387
facial, anastomosis for, 732, 733
muscle transplantation for, 733
peripheral, 731
treatment, 732
honeymoon, 450
in tumors of brain, 716
ischemic, 433
Klumpke, 447
medullary, 703
musculospiral, in anesthesia, 540
of anterior crural nerve, 456
of axillary nerve, 449
of brachial plexus, 447
from cervical rib, 448
lower-arm type, 447
of cauda equina, 457
of circumflex nerve, 449
of common peroneal nerve, 458
of cranial nerves, 725
of esophagus, 866
of external popliteal nerve, 458
of femoral nerve, 456
of internal popliteal nerve, 459
of lateral femoral cutaneous nerve, 457
of long thoracic nerve, 448
of median nerve, 451
of musculocutaneous nerve, 449
of musculospiral nerve, 449
of obturator nerve, 456
of radial nerve, 449
of sacral plexus, 457
of sciatic nerve, 457
of serratus muscle, 384
of superior gluteal nerve, 456
of suprascapular nerve, 449
of thenar muscles, treatment, 387
of tibial nerve, 459
of trapezius muscle, 384
of ulnar nerve, 455
Froment's sign, 455
radial, *506*
Saturday-night, 450
secondary, after spinal anesthesia, 574
wood-tick, 61
Paralytic flat-foot, 1307
rabies, 154
talipes, 1308
Parangi, 167
Paraphimosis, 1277
Paraplegia complicating skull injuries, 708
from Pott's disease, 770
gravitation, 766
Paras, 747
Parasacral anesthesia, 576
Parasites, animal, in bladder, 1256
intestinal, in appendix, 1097
malarial, 65
Parasitic cysts, 222
of breast, 896
of pancreas, 1153
onychia, 474
Parasitic theory of tumors, 183
Parathyroid deficiency, gastric tetany in, 1031
injury complicating operations on thyroid, 488
Paravertebral anesthesia, 575, 577
triangle of dulness in purulent pleurisy, 915
Paré, 400, 554, 641
Parenchymatous goiter, 476, 477
simple, 479
inflammation, 21
Paresthesia of great auricular nerve, 851
radium, of jaws and neck, 850
roentgen-ray, of jaws and neck, 850
Parham-Martin band, 271
Parietal nerves of abdominal wall, 954
Parker-Kerr basting-stitch method of aseptic intestinal anastomosis, 1090
Parkhill, 271
Parkhurst, 219
Parkinson, 186
Paronychia, 473
Parosmia, 725
Parosteal fibrosarcoma, 245
osteoma, 189, 242
Parotid bubo, 828
duct, 825
open division, 825
subcutaneous rupture, 825
gland, actinomycosis, 829
anatomy, 825
angioma, 829
cancer, 829
fibroma, 829
inflammation, 828
lipoma, 829
lymphangioma, 829
mixed tumor, 829
myxoma, 829
sarcoma, 829
syphilis, 829
tuberculosis, 829
tumors, 829
Parotitis, acute, 828
suppurative, 828
chronic, 829
epidemica, 828
purulenta, 828
specific, 828
Parrot's nodes, 683
Parry's disease, 479
Partsch's operation for dental cysts, 815
Parulis, 807
Passet, 141
Paste injection into lung, embolism from, 934
Pasteur, 141, 146, 148, 153
Pasteur's preventive inoculation of rabies, 155
Patella, dislocation, 374
congenital, 374
lateral, 374
edgewise, 374
lateral, 374
medial, 374
vertical, 374
floating, 331
fracture, 317
transverse, 317
Paterson, 1052
Patheticus nerve, lesions, 726
Pathologic fracture, 257
milk, 100
Paul-Mixter glass intestinal tube for enterostomy, *1093*
Paulson, 503
Payr, 271
Payr's crushing forceps, *1050*
disease, 990, 1068
Péan, 1045
Peanut bronchitis, 924
Pearl and Brunn, 1034
Pearly bodies, 204
Pearson, 269
Peck and Goldheizer, 169
Pectineal hernia of Cloquet, 1196
Pectus carinatum, 872
excavatum, 872
gallinatum, 872
Pedicle needle, 603
Pediculi, bites of, 60
Pel-Ebstein syndrome, 426
Pelvic colon, carcinoma of, *1219*

Pelvic kidney, 1222
tumors, spinal tumors and, differentiation, 779
Pelvirectal abscess, 1209
Pelvis, false, fracture, 301
fracture, 301
of kidney, drainage, 1242
incision, 1242
infection, 1233
tumors, 1242
osteogenic sarcoma, 246
scoliotic, 768
true, fracture, 301
Penetrating ulcer, 31
wounds, 36
Penile fistula complicating urethral stricture, 1271
hypospadias, 1278
Penis, 1277
cancer, 1280
congenital anomalies, 1277
continuous erection, 1279
dislocation, 1278
double, 1278
epithelioma, 1280
fracture, 1278
glans, inflammation, 1279
herpetic eruption, 1280
meatus, atresia of, 1277
stenosis of, 1277
stricture of, 1277
moist gangrene, 1280
rupture, 1278
subluxation, 1278
torsion, 1278
tuberculosis, 1280
tumors, 1280
wounds, 1278
Pennington's proctoscope, *1217*
Penrose, 55
Pentastomum denticulatum, 60
tænioides, 60
Pepper, 939, 1034
Pepper's treatment in peritonitis, 982
Peptic ulcer, 1005
appendicitis and, differentiation, 1017
carcinoma of stomach and, differentiation, 1017
cholecystitis and, differentiation, 1017
diet in, 1008
gall-stones and, differentiation, 1017
in chronic appendicitis, 1106
locomotor ataxia and, differentiation, 1017
perforated, 1009
acute hemorrhagic pancreatitis and, differentiation, 1011
appendicitis and, differentiation, 1103
carcinoma of stomach and, differentiation, 1011
cholecystitis and, differentiation, 1140
treatment, 1011
pulmonary tuberculosis and, differentiation, 1017
suspected, routine treatment, 1008
Percussion in fractures, 261
of esophagus, 861
of kidney, 1223
Percy electric cautery, 597
Perforated duodenal ulcer, *977*, *978*, *1014*, 1015
acute appendicitis and, differentiation, 1011
gastric ulcer, 1009
abscess secondary to, 1012
acute, 1009
chronic, 1010
subacute, 1010
treatment, 1011
jejunal ulcer, 1020
peptic ulcer, 1009
acute hemorrhagic pancreatitis and, differentiation, 1011
appendicitis and, differentiation, 1103
carcinoma of stomach and, differentiation, 1011
cholecystitis and, differentiation, 1139
Perforated peptic ulcer, treatment, 1011
ulcer in typhoid, 1070
Perforating ulcer, 31, 463
treatment, 33
wounds, 36
of stomach, 1001
Perforation, chronic, of bladder, 1251
of stomach, *1002*
Perforative appendicitis, acute, 1101
Peri-appendiceal abscess, localized, 1101
Periarteritis nodosa, 392
syphilitic, 393
Periarticular fractures, 257
Pericanalicular fibroma, 187
Pericardial tamponades, 944
Pericardiomediastinitis, adhesive, 945
Pericardiotomy for pyopericardium, 947
for tuberculous pericarditis, 947
median thoraco-abdominal, 949
Pericarditis, adhesive, 945
cardiolysis in, 945
purulent, 945
tuberculous, pericardiotomy for, 947
Pericardium, aspiration, 947
Duval Barasty incision for, *949*
puncturing, different points for, *944*
Perichondritis, laryngeal, 839
Pericolic adhesion, 990
Peridiverticulitis, intestinal stricture in, 1066
Periductal fibroma of breast, 896
Periesophagitis, 865
Perihepatitis, chronic, 1127
Perilymphadenitis, 422
Perilymphangitis, 422
Perineal excision of rectal carcinoma, 1220
hernia, 1204
hypospadias, 1278
litholapaxy, Keith's, 1254
lithotomy, 1254
prostatectomy, 1275
Perinephric abscess, 1235
Perinephritis, 1235
tuberculous, 1237
Periodical vomiting, 1033
Periodontitis, 807
Periodontal abscess, 807
Periosseous fibrosarcoma, 245
Periosteal elevators, 598
osteoma, 189
movable, 242
sarcoma, 245
Periosteotome, Babcock's costal, *920*
Periostitis, acute, 230
of hyoid, 850
arsenical, of jaw, 809
chronic, 230
mercurial, of jaws, 809
of jaw, 808
ossifying, 190
phosphorus, of jaws, 809
tuberculous, 237
of jaw, 810
Peripheral anesthesia, 554
facial paralysis, 731
nerves, 429
combing of fibers, 438
compression, 430
contusions, 430
disassociation of fibers, 438
division, 430
diagnosis, 433
pathology, 431
suture, 439
symptoms, 431
exploration operation, 436
gaps in, adduction or rotation of adjacent joints for, 441
after-treatment, 444
direct implantation of nerve into muscle for, 443
elongation for, 443
flexion and extension of adjacent joints for, 441
nerve-grafting for, 443
neurectasis for, 443
rerouting for, 441
treatment, 440
hersage, 438
injuries, 430
interruption, symptoms, 431
laceration, 430
Peripheral nerves, motor tests to determine conductivity, 437
neurolysis, 437
neurorrhaphy, 439
operations, 436
physiology, 429
regeneration, symptoms, 433
Tinel's sign, 433, 445
retractor for, *443*
sensory conductivity electrical tests to determine, 436
stretching, 430
transplantation, 619
tumors, 459
operations to relieve cerebral spasticity, 783
Perirenal hematoma, 1227
Peristalsis, excessive, 1033
nerves initiating, 954
Perithelial sarcoma, 201
Perithelioma of spine, 774
Peritoneal surfaces, after-suture of, 1086
wounds, healing of, 1085
Peritoneosaphenous anastomosis for ascites, 994, *995*
Peritoneum, 975
absorption from, 979
actinomycosis, 993
antiseptics in, 984
carcinoma of, secondary, 996
cysts, 996
diseases of, causing ascites, 993
drainage, 983
endothelioma, 996
foreign body in, 977
inflammation, 975
following appendectomy, 1115
operations on, preoperative treatment, 586
pyogenic bacteria in, 976
sarcoma, 996
tumors, 996
secondary, 996
Peritonitis, 975
actinomycotic, 993
Alonzo Clark treatment, 982
cause of death, 981
chronic, 989
adhesive, 989
special varieties, 990
colon bacillus as cause, 976
diagnosis, 981
drainage in, 983
drains, dangers of, 984
removal of, 984
types of, 983
early, 979
enemas in, 985
enteric bacilli as cause, 976
facies hippocratica in, 980
following appendectomy, 1115
feeding in, 1116
general toxemia in, 980
gonococcus, 976
gonorrheal, 148
in appendicitis, 1102
inflammatory ileus in, 980
jejunal toxemia in, treatment, 984
latent, 979
localization, 985
Ochsner treatment, 982
operation in, 982
anesthetic for, 982
danger in manipulation, 983
indications for delay, 982
pathology, 977
Pepper treatment, 982
period of active inflammation and toxemia, 980
pneumococcus, 976, 985
abdominal empyema in, 985
appendicitis and, differentiation, 986
circumscribed, 985
diffuse, 985
treatment, 986
postoperative treatment, 984
predisposing factors, 975
preoperative treatment, 984
proctoclysis in, 985
prognosis, 981
purulent fibrin in, 976
secondary, 976
from perforation of duodenal ulcer, *977*

Peritonitis secondary to appendiceal abscess, *980*
to perforated duodenal ulcer, *977*, *978*
serous, 21
Staphylococcus albus as cause, 976
aureus as cause, 976
streptococcus, 976
symptoms, 979
ominous, 982
terminal stage, 980
treatment, 982
tuberculous, 990
ascites in, 992
Banti's disease and, differentiation, 992
caseous, 991, 992
fibrous or adhesive, 991, 992
lymphoglandular, 991
ovarian cysts and, differentiation, 992
treatment, 992
varieties, 975
order of virulence, 981
Peritonsillar abscess, 831
tissues, suppuration, 831
Perityphlitis, 1074
Periurethral abscess complicating urethral stricture, 1271
cellulitis complicating urethral stricture, 1270
Perivascular infection of carotid sheath, 853
Perkins, 1250
Perlingual administration of drugs, 503
Permanganate of potash as wet dressing for wounds, 50
of potassium, 137
Pernasal administration of drugs, 503
Pernicious anemia, 1161
blood-transfusion in, 1161
radium treatment, 1161
splenectomy for, 1161
Pernio, 73
Perodactylism, 1289
Peromelus, 1289
Peroneal artery, ligation, 640
nerve, common, injuries, 458
Persistent ductus arteriosus, 943
Perthes, 1164
Perthes' angular incision, 974
Perthes-Calvé disease, 1302
Pes cavus, 1307, *1309*
gigas, 1300
planus, 1304
valgus, 1304
Petechia, 78
Peter's operation for exstrophy of bladder, 1249
Peterson, 1045
Petit, 416, 641
Petit's tourniquet, 81
Pétrissage, 516
Petroquin, 404
Pezzer catheter, *1258*
Pfahler, 196, 936
Pfannenstiel's incision, *973*, 974
Phagedena, tropical, 179
treatment, 180
Phagedenic ulcer, 29
gangrene, 109
ulcers, treatment, 32
Phagocytosis, 26
Phalanges, dislocation, 364
fractures, 300, 327
proximal, 300
of hand, multiple enchondromas, *243*
Phalangization method, 620
Phalanx, terminal, flexion of, from rupture of extensor tendon, 366
of thumb, comminuted fracture, 301
Phantom foot, 644
hand, 644
Pharyngitis, acute, 830
chronic, 830
Pharyngotomy, 844
subhyoid, 844
suprahyoid, 844
transhyoid, 844
Pharynx, 830
burns and scalds, 70
foreign bodies in, 833
Pharynx, hemorrhage, 830
inflammation, 830
stenosis, 830
tumors, 830
Phenacain, local anesthesia by, 560
Phenol as disinfectant, 133
solutions as wet or moist dressing for wounds, 50
Phenolsulphonephthalein test of kidney function, 1226
Philagrius, 407
Philetus, 404
Phillip's cecostomy, 1094
Phimosis, 1277
acquired, 1277
congenital, 1277
of mouth, 784
Phisalix, 56
Phlebectasia, 414
Phlebitis, 411
chronic, 413
Mahler's symptom, 413
migrans, 413
saphenous, 412
sinus, 413
cerebral, 711
treatment, 413
treatment, 413
Phlebolith, 417
Phlebotomy, 418, 515
Phlegmasia alba dolens, 99, 411, 412
Phlegmon, 27
ligneus, 854
of Chassaignac, 853
orbital, 793
woody, 854
Phlegmonous appendicitis, 1101
erysipelas, 144
gastritis, 1004
gastroduodenitis, 1004
inflammation, 21
Phloridzin test of kidney function, 1226
Phocomelus, 1289
Phosgene, effects of, 71
Phosphatic stones in intestine, 1061
Phosphorus necrosis of jaw, 809
periostitis of jaws, 809
Phossy jaw, 809
Phrenic avulsion, 942
exeresis, 942
nerve, division of, 942
lesions, 737
Phrenicotomy, 942
Phrenospasm, treatment, 869
Phthisis. See also *Tuberculosis, pulmonary.*
acute pneumonic, 935
fibroid, 935
florida, 935
Physaliphores, 193
Physiologic saline with epinephrine to stimulate arrested heart, 947
Phytobezoar, 1003
in intestine, 1061
in stomach, 1003
Pia, hemorrhage from, control, 705
Pia-arachnoid, inflammation, 773
Pian, 166
Pick's disease, 944
Picque, 943
Picric acid, 137
Pied de Madura, 175
Pieri, 620
Pieri's method of Z plasty, 1295
operation for syndactylism, 1292, *1294*
Pigeon-breast, 223, 872
Pigeon-toe, 1311
Pigmentation of skin, 461
Pigmented nevi, 801
Pig-skin, cancerous, *903*
Pilcher's solution, 110
Piles, 194, 414, **1212**. See also *Hemorrhoids.*
Pilonidal cysts, 468
fistula, 468
sinus, 758
Pin, Steinmann's, 268
Pin-worm, 62
Pineal body, diseases, 498
tumors, 498
Ping-pong crackling in sarcoma of bone, 244
Pins, Wyeth's, *645*
Pipe-stem stools in stricture of rectum and anus, 1217
Pirogoff, 545
Pirogoff's amputation of ankle, 656
Ferguson's modification, 656
Le Fort's modification, 656
Pisces, injuries received from, 56
Pituitary body, 490. See also *Hypophysis cerebri.*
hibernation, *491*
struma, 493
Pituitrin, 490
Pityriasis of tongue, 822
Plantar bursitis, anterior, 389
Plantaris, rupture, 1304
Plasma-cells, 26
Plaster spreading forceps, 530
Plastic motor amputation, 642
operations on breast, 910
resection of breast, 910
surgery, 607
obtaining approximation, 608
thoracoplasty, 922
urethrotomy, 1270
Plates, Lane's, 270
Sherman's, 270
Plating of fractures, 270, 271
Platycephalic skull, 669
Pleura, 912
carcinoma, secondary, 918
drainage, in empyema, *916*
en blocquées, 918
endothelioma, 918
foreign bodies in, 917
great thickening of, and empyema, differentiation, 915
hemorrhage into, 913
inflammation, 912
sarcoma, 918
secondary, 918
tumors, 917
Pleuracostomy, 919
Pleuracotomy, major intercostal, 920
minor intercostal, 919
Pleural effusion, 912
chylous, 913
gaseous, 913
hemorrhagic, 912
pseudochylous, 913
purulent, 914
serous, 912
subphrenic abscess and, differentiation, 988
shock, 933
Pleurectomy, visceral, 921
Pleurisy, appendicitis and, differentiation, 1104
blocked, 918
purulent, 27, **914**
bacteria causing, 914
clinical varieties, 914
egophony in, 915
Ellis' S-shaped line in, 915
following influenza, 914
pneumonia, 914
great thickening of pleura and, differentiation, 915
Grocco's paravertebral triangle of dulness in, 915
lung neoplasms and, differentiation, 915
pneumonia and, differentiation, 915
pus-clot in, 914
skodaic resonance in, 915
subphrenic abscess and, differentiation, 915
treatment, 915
ultra-acute, 914
serous, 21
Pleuritis exudativa serosa, 912
Pleurodynia, 382
Pleurotomy, visceral, 922
Plexiform aneurysm, 396
angioma, 194
neuroma, 190, 459
of scalp, 669
sarcoma, 201
Plexus anesthesia, 554
brachial, infraclavicular rupture, 446
lesions, 446
paralysis, 447
from cervical rib, 448
lower-arm type, 447

Plexus, brachial, paralysis, treatment, 448
supraclavicular rupture, 446
postfixed, 847
sacral, injuries, 457
Plummer, 481, 483
Pneumatic tourniquet, 82
Pneumatocele, 667
Pneumectomy, cautery, in bronchiectasis, 933
in bronchiectasis, 933
Pneumococcal arthritis, 334
cystitis, 1255
Pneumococcic meningitis, 688
Pneumococcus, 146
infection, 146
meningitis, 146
peritonitis, 976, 985
appendicitis and, differentiation, 986
circumscribed, 985
diffuse, 985
treatment, 986
Pneumogastric nerve, lesions, 735
Pneumography, Dandy's method, 746
Pneumolysis, 921, 941
of Friedrich and Brauer, 941
Pneumonia, anesthesia in, 537
appendicitis and, differentiation, 1104
bronchial, acute tuberculous, 935
subacute tuberculous, 935
caseous, 935
croupous, abscess of lung from, 928
delirium of, 120
empyema and, differentiation, 915
epithelial, 935
inhalation, in anesthesia, 538
purulent pleurisy following, 914
thrombosis in, 94
Pneumoperitoneum, artificial, 956
Pneumoradiography of kidney, 1225
Pneumothorax, 913
artificial, 940
in abscess of lung, 929
in bronchiectasis, 932
Loving's pressure apparatus, *940*
technic, 941
in thoracentesis, 918
open physiologic changes in, 877
treatment, 880
Pneumotomy in lung abscess, 929
Pocket, accessory, in gastric ulcer, 1007
Podelkoma, 175
Point, Keen's, 699
Kocher's, 699
of contrecoup, 700
Pointed toe, 1304
prevention, 313
Pointing of abscess, 27
test of Bárány, 694
Poisoned wound, 36
Poisoning, iodoform, 138
opium, cerebral compression and, differentiation, 703
war-gas, 71
treatment, 72
Poker back, 767
Policeman's heel, 387, **1310**
Pollakiuria, 1224
in acute appendicitis, 1100
Pollender, 152
Polya, 1045
Polya-Reichel method of partial gastrectomy, *1039*, 1052
Polyadenoma en nappe, 1034
of stomach, 1034
Polyarthritis, atrophic, 340
syphilitic, 338
Polycystic kidney, 1239, *1240*
Polycythemia rubra, 1161
vera, 1161
Polydactylism, 1289
Polyglandular syndrome, *491*, 492
Polygnathia, 785
Polymastia, 888
Polymazia, 888
Polyorchidism, 1281
Polyorrhomenitis, 995
Polyotia, 845
Polyp, adenomatous, 203
of upper lip, *203*
fibrous, 187
gastric, 1034, 1035
discrete, 1034
Polyp, mucous, 188
of rectum, mucous, 1218
postpharyngeal, 830
Polyposis of colon, *1079*
of stomach, 1034, 1035
Polypus of gums, 819
Polyserositis, 995
Polythelia, 888
Polytrichia, 462
Poncet, 466
Pond fracture, 255, 671
Poor man's bandage, 528
Popliteal aneurysm, Matas' operation, *405*, *406*
artery, digital compression, 81
ligation, 638
bursa, inflammation, 390
nerve, external, injuries, 458
internal, injuries, 459
space, ganglion, 390
Pork tapeworm, 64
Portal cirrhosis, 1126
obstruction, collateral circulation in, 993
system, accessory, of Sappey, 1126
vein, inflammation of, 1124
following appendectomy, 1115
Porte moxa, 516
Porter, 487, 889
Porter's wart, dissecting, 467
Port-wine mark, 194, 799
stain, 469
Position in arrest of hemorrhage, 83
left lateral semiprone, *1209*
Sims', *1209*
Trendelenburg's, *1216*
inverted, *1220*
Postadolescent myxedema, 478
Postanal dimple, 758
teratoma, 758
Postepileptic coma, 118
Postfixed plexus, 847
Postmortem intussusception, 1062
Postoperative complications of appendicitis, 1114
dressings, 592
hernia, 1167
myxedema, 478
supporting bandage, 592
thrombosis, 95
treatment, 580, **588**
asthenia, 589
coma, 589
constipation, 593
dehydration, 589
delirium, 589
diet, 592, 593
excitement, 589
for clean abdominal sections, 588
for operations not abdominal, 588
for septic abdominal section, 589
hemorrhages, internal, 591
hiccup, 590
immediate, 589
insomnia, 590
mania, 589
operations on biliary system, 594
pain, 590
restlessness, 590
resuming work, 592
sepsis, 591
shock, **589**, 591
stupor, 589
Postpharyngeal abscess, 770, **830**
polyp, 830
Posttraumatic hypopituitarism, *491*
Postural scoliosis, 768
Potain's aspirator, *515*
Potash, permanganate of, as wet dressing for wounds, 50
Potassium mercuric iodid as antiseptic, 135
permanganate, 137
Potato nose, 463, **798**
Potato-like tumor of neck, 859
Pott, 668, 769
Pott's asthma, 489
disease, 769
Albee's operation, 771
diagnosis, 770
osteomyelitic form, 769
paraplegia from, 770
periosteal form, 769
Pott's disease, pressure upon spinal cord and roots in, 773
prognosis, 770
treatment, 771
of complications, 772
fracture, 324
puffy tumor, 668
Poultice, antiseptic, for wounds, 49
Powder dressing of wounds, 47
Powders, anesthetic, for wounds, 47
antiseptic, for wounds, 48
aseptic, for wounds, 47
bismuth, for wounds, 48
inhalation of, 925
protective, for wounds, 47
Powell's operation for varicose veins, 417
Pox, 161
Pozzi, 217
Preacetabular bursitis, femoral hernia and, differentiation, 1197
inguinal hernia and, differentiation, 1184
Preadolescent hypothyroidism, 478
Preauricular fistulæ, 790
Precancerous dermatosis, 208, 471
Bowen's, 209
lesions, symptoms, 208
Pregnancy, gall-stones in, 1132
Premammary abscess, *889*, 892
Preoperative diet, 586
examinations, exhausting, 587
preparation for prostatectomy, 1275
purgation, 586
treatment, 580, **584**
conservation of body heat, 587
for abdominal operations with peritonitis or intestinal obstruction, 588
for operations involving abdominal cavity without evidence of peritonitis or other infections, 587
not involving abdominal cavity, 587
gastric anacidity, 586
mucous surfaces, 586
routine, 587
skin, 586
Prepatellar bursa, inflammation, 390
Preputial calculi, 1279
Presacral anesthesia, 575
Presenile gangrene, 105
spontaneous gangrene, 105
Pressure diverticula of esophagus, 866
in arrest of hemorrhage, 83
sense, 429
ulcer, 30, *31*
treatment, 33
Priapism, 1279
Price's elbow, 990, 1068
Prickle-cell cancer, 210
Priestley, 548
Pritchett and Bull, 110
Probe, Jackson's, *925*
Probes, 599
Procain, local anesthesia by, 558
Procession caterpillar, irritation of skin from, 59
Processus xiphoideus bifidus, 872
Procidentia recti, 1214
complete, *1214*, 1215
incomplete, 1214
operations, 1215
reduction, 1215
Proctectomy for rectal stricture, 1217
Proctitis, 1206
Proctoclysis, 504
in peritonitis, 985
Proctopexy for prolapse of rectum, 1215
Proctorrhaphy for prolapse of rectum, 1215
Proctoscope, Pennington's, *1217*
Proctotomy for rectal stricture, 1217
Productive inflammation, 21, 22
Profeta's law in syphilis, 163
Prognathia, 785
Prognathism, inferior, 805
Progressive gangrenous infection of skin, 466
Prolapse, definition, 1165
of ascending colon, Waugh's operation, *1088*
of lung in wounds of chest, 879
of rectum, 1214

Prolapse of rectum, amputation, 1216
colopexy for, 1215
complete, *1214*, 1215
DeLong's operation, 1215
incomplete, 1214
Lorimer's operation, 1215
Moschcowitz's operation, 1215
operations, 1215
proctopexy for, 1215
proctorrhaphy for, 1215
rectopexy for, 1215
reduction, 1214
of spleen, 1159
of stomach, 1027
rectal, 1215
rectal-sphincteric, 1215
rectorectal, 1215
Proliferative cysts of pancreas, 1153
infection, 125
Properitoneal fascia, 1194
hernia, 1166
inguinal hernia, 1181
lipoma, 192, 1202
Propinquity infection of gall-bladder, 1136
Proptosis and edema of eyelid from cavernous sinus thrombosis, *712*
Prostate, 1272
calculus, 1275
carcinoma, 1276
cysts, 1273
hypertrophy, 1273
roentgen rays in, 517
inflammation, 1272
tuberculosis, 1276
wounds, 1272
Prostatectomy, 1275
perineal, 1275
preoperative preparation, 1275
suprapubic, 1275
Prostatic abscess, gonorrheal, treatment, 1264
hematuria, 1223
obstruction, operation on, preoperative treatment, 585
pyuria, 1224
Prostatitis, acute, 1272
chronic, 1273
gonorrheal, acute, treatment of, 1264
chronic, 1265
Protargin, mild, 136
Protective powders for wounds, 47
Protein metabolism in hepatic disease, 1120
shock, 22
therapy, non-specific, 513
Protein-shock treatment in gonorrheal arthritis, 334
Protopathic sensation, 433
sense, 429
Protozoa, 65
Proud flesh, 29
Provisional splint, 531
Prowazek, 161
Pruritus ani, 1216
Ball's operation, 1216
Psammoma, 201
of spine, 775
Pseudarthrosis, costal, 942
Pseudochylous fluid, 913
Pseudocoxalgia, 240
Pseudocysts of pancreas, 1153
Pseudogoundou, 176
Pseudoplasms, 181. See also *Tumors*.
Pseudorheumatism, syphilitic, 338
Pseudo-white swelling, 339
Psoas abscess, 769, 770, 915
femoral hernia and, differentiation, 1197
inguinal hernia and, differentiation, 1183
Psoriasis buccalis, 821
Ptosed spleen, 1158
Ptosis of ascending colon and cecum mobile, Waugh's operation, *10 9*
Pubic dislocation of hip, 370
Puerperal tetanus, 149
Puffy tumor, Pott's, 668
Pulex irritans, 60
Pulled elbow, 361
Pulmonary actinomycosis, 172
anthrax, 153
artery, branches, ligation of, 942
arthropathy, hypertrophic, 229
Pulmonary complications following gastro-enterostomy, 1023
of anesthesia, 535
decortication, 921
edema, 927
embolectomy, 98
hemorrhage, 927
osteo-arthropathy, hypertrophic, 190
thrombectomy, 98
tuberculosis, 935. See also *Tuberculosis, pulmonary*.
Pulpitis, acute, 807
Pulsating hematoma of bone, 253
Pulse rate in anesthesia, 536
Pulsion diverticula of esophagus, 866
Puncture, cisternal, 779
cisterna-magna, 747
headache, 509
lumbar, in brain tumors, 721
of lateral ventricles in internal hydrocephalus, 699
spinal, danger of, from foraminal hernia when intracerebral pressure is increased, *698*
in brain tumors, 721
Punctured fractures of skull, 673
wounds, 36, **43**
treatment, 44
Purgation, preoperative, 586
Purpura, 460
acute toxic, 1162
chronic, 1162
fulminans, 1162
hæmorrhagica, 1161
tourniquet test, 1161
Henoch's, 460
Purse-string suture for appendectomy, *1111*
Purulent catarrh, 21
cholecystitis, 27, *1137*
exudation, 20
fibrin in peritoneum, 976
inflammation, 21
meningitis, 774
nephritis, 1234
pericarditis, 945
pleurisy, 27, **914**. See also *Pleurisy, purulent*.
tenosynovitis, 384
Pus, 26
dead, 26, **27**
in urine, 1224
infectious, 26
laudable, 26
living, 26
sanious, 26
septic, 26, **27**
sterile, 26
Pus-clot in purulent pleurisy, 914
Pus-corpuscles, 26
Pus-kidney, 1234
Pus-serum, 26
Pustular inflammation, 21
lesions of skin, roentgen rays in, 517
Pustule, 21, 141
malignant, 152
of scalp, 668
Putti's sculptural chisels, *344*
Pyarthrosis, 27
Pyelitis, 1233
from renal calculus, 1230
Pyelogram, dragon, 1225
Pyelography, 1225
Pyelolithotomy, 1231, 1242
Pyelonephrosis, 1234
from renal calculus, 1230
Pyelostomy, 1242
Pyelotomy, 1242
Pyemia, 126
Pyemic abscess, 27
of liver, 1123
actinomycosis of intestines, 1078
arthritis, 335
Pylephlebitis, 413, 1124
Braun's operation for, 1124
in appendicitis, 1102
postoperative, in appendicitis, 1115
septic, 95
Pylons, 649
Pylorectomy, historical, 1045
Pyloric obstruction, 1026
occlusion in duodenal ulcer, 1016
stenosis, 1026
hypertrophic, 1031
Pylorodiosis, 1047
Hahn's, 1047
Loreta's, 1047
Pyloroplasty, 1049
historical, 1045
Ramstedt's method, *1000*
Pylorotomy, 1049
for congenital stenosis of pylorus, 1000
Pylorus, stenosis of, congenital hypertrophic, 999
pylorotomy for, 1000
Pyoctanin, 138
Pyogenes, Streptococcus, 143
Pyogenic abscess of liver, 1122
bacteria, 141
infection, 125
membrane, 27, 238
Pyonephritis, 1234
Pyonephrosis, 1234
Pyopericardium, 27
pericardiotomy for, 947
Pyopneumothorax, 913
in tuberculosis, 913
Pyorrhea alveolaris, 819
salivaris, 827
Pyothorax, 27, **914**
Pyrogallol in cancer, 216
Pyuria, 1224
prostatic, 1224
vesical, 1224

Queckenstedt's test of cerebrospinal pressure, 738, **744**
Quiet necrosis, 230, **236**
Quincke, 939
Quincke's operation, 941
serous meningitis, 697
Quinin and urea, hydrochlorid of, local anesthesia by, 560
Quinsy, 831

Rabies, 153
dumb, 154
furious, 154
paralytic, 154
treatment, 155
Racemose adenoma, 203
Rachianesthesia, 561
Rachischisis, 747
prognosis, 752
Rachitis, 223. See also *Rickets*.
Racket incision for amputation of leg, 646
Radial artery, ligation, 633
nerve, injuries, 449
paralysis, treatment, 451
palsy, *506*
Radiation burn, 73
depilation, 463
dermatitis, 209
Radicular anesthesia, 561
dental cysts, 814
odontoma, 205
syndrome, middle, 447
upper, 447
Radio knife, 597
in cancer, 217
Radiocarpal articulation, dislocation, 363
Radiography of esophagus, 860
spinal, 746
Radiotherapy in cancer, 218
Radium burn, 76
dermatitis, 67
in cancer, 217, **218**
of tongue, 824
in lung tumors, 937
in pernicious anemia, 1161
knife in arrest of hemorrhage, 83
paresthesia of jaws and neck, 850
Radius and ulna, both, fracture, 297
synostosis, 1290
dislocations, 358, **361**
head, 361
epiphysis, lower, separation of, 297
fracture, 292. See also *Fractures of radius*.
osteogenic sarcoma, 246
Railway spine, 759
Raised hemangioma, 469
Rammstedt's operation for congenital stenosis of pylorus, 1000

Rankin's forceps, 1092
Ransohoff, 579, 922
Ranula, 220, **821**
  pancreatic, 1153
Ranvier, 181
Rash, wandering, on tongue, 822
Rasmussen's aneurysm, 398
Rat skin, 798
Rat-bite fever, 168
Rats, injuries and diseases received from, 56
Ray-fungus, 170
Raynaud's disease, 107
Reaction of degeneration, 432
Reamputation, 644
Receding chin, *619*, 805
  correction, *619*
Recklinghausen's disease, **228**, 459, 858
  of chest, 884
  of scalp, 669
Reclus' disease, 854, **896**
Reconstructive aneurysmorrhaphy, 408
  operations on hip, 371
Rectal dermoids, 220
  ether anesthesia, 545
    in childbirth, 546
  fistula complicating urethral stricture, 1271
  hernia, 1215
  infusion, 504
  prolapse, 1215
  shelf, Blumer's, 1037
  speculum, Martin's, *1210*
  tenesmus, 1207
Rectal-sphincteric prolapse, 1215
Recti muscles, diastasis of, 1201
  divarication of, 1200
Rectopexy for prolapse of rectum, 1215
Rectorectal prolapse, 1215
Rectosigmoid, carcinoma of, Coffey's operation, 1221
Rectum, 1206
  abscess, 1207
    cutaneous, 1207
    subcutaneous, 1208
  adenocarcinoma, 1218
  adenoma, 1218
  carcinoma, 1218
    Coffey's operation, 1221
    colloid, 1218
    formation of abdominal anus in, 1220
      of combined sacral and abdominal anus in, 1221
      of lumbar anus in, 1220
      of sacral anus in, 1220
    Kraske's operation, 1220
    medullary, 1218
    perineal excision, 1220
    sacral operation, 1220
    scirrhous, 1218
    vaginal excision, 1220
  cocain anesthesia, 557
  congenital malformations, 1206
  foreign bodies in, swallowed, 1061
  hemorrhage from, treatment, 89
  hernia, 1215
  imperforate, 1206
  inflammation, 1206
  lower, carcinoma of, Coffey's operation, 1221
  operations on, preoperative treatment, 585
  oxyuris vermicularis infection, 1206
  papilloma, 1218
  polyp, mucous, 1218
  prolapse, 1214
    amputation, 1216
    colopexy for, 1215
    complete, *1214*, 1215
    De Long's operation, 1215
    incomplete, 1214
    Lorimer's operation, 1215
    Moschcowitz's operation, 1215
    operations, 1215
    proctopexy for, 1215
    proctorrhaphy for, 1215
    rectopexy for, 1215
    reduction, 1215
  sarcoma, 1221
  stenosis, 1216
  stricture, 1206, **1216**
    inflammatory, 1217
    malignant, 1217
Rectum, stricture, organic, 1216
    pipe-stem stools in, 1217
    proctectomy for, 1217
    proctotomy for, 1217
    ribbon stools in, 1217
    spasmodic, 1217
    traumatic, 1217
  syphilis, 1217
  tumors, benign epithelial, 1218
  upper, carcinoma of, Coffey's operation, 1221
Rectus incision, 972
Recurrent bandage, 521
  of head, *523*, *524*
  dislocation, 349
    of head of ulna, 363
    of shoulder, 358
  fibroid of Paget, 200
  nerve, injury, 852
    lesions, 736
Red bug, 60
  fleas, 60
Redness as symptom of inflammation, 22
Reducible hernia, 1167
Redwitz, 146
Reef knot, 607
Reflex arc, visceral, 954
  micturition, 741
  torticollis, 848
Reflexes, spinal, 741. See also *Spinal reflexes.*
Regeneration of connective tissue, 25
  of kidney, 26
  of nerve, 26
  of peripheral nerves, **433**, 445
    Tinel's sign, **433**, 445
  of striped muscle, 26
  of tissues, 24
Regional anesthesia, 534
  surgery, 664
  vascular anesthesia, 554
Rehn, 949
Reichel, 1045
Reichel-Polya method of partial gastrectomy, *1030*, *1039*, 1052
    Balfour's modification, *1039*
Reichert, 56
Reichmann's disease, 1033
Reid's base line, 693
Reimplantation of completely separated parts without a vascular connection, 620
Relaxation of anterior abdominal wall, 963
Relaxing sutures, *604*
Renal, 1222. See also *Kidney.*
  artery, aneurysm, 1240
  calculus, 1228
  colic, appendicitis and, differentiation, 1103
    cholecystitis and, differentiation, 1140
    from calculus, 1230
  function, 1225
    blood-urea test, 1226
    chromocystoscopy test, 1226
    cryoscopy test, 1226
    indigo-carmine test, 1225
    phenolsulphonephthalein test, 1226
    phloridzin test, 1226
    urea-concentration test, 1226
  pelvis, tumors, 1242
  tuberculosis, 1236
Repair of fractures, 259
  of tissue, 24
Resection of gasserian ganglion in trifacial neuralgia, 729
  of intestines, aseptic, 1090
  of stomach, coat-sleeve, 1052
    midgastric, 1052
  of sympathetic nerves, 783
  of urethra for stricture, 1270
Resin cerate for burns, 70
  plaster in fractures, 263
Resonance, skodaic, in purulent pleurisy, 915
Respiration, artificial, 500. See also *Artificial respiration.*
  effect of spinal anesthesia upon, 563
Respiratory nerve, external, of Bell, injury, 448
  tract in anesthesia, 537
Restlessness, postoperative treatment, 590
Resuscitation, 500
  by artificial respiration, 500. See also *Artificial respiration.*
  in operating-room, 583
Retained testes, 1281
Retention cysts of breast, 895
    of pancreas, 1153
    of sebaceous glands, 468
  of urine, 1246
    complicating urethral stricture, 1270
Reticulated epithelioma, 214
Reticulo-endothelial system, 77
Retractor, 601
  Babcock's abdominal, *601*, *880*
    Balfour's self-retaining, *1066*
  Farr's, *487*
  for appendiceal incision, *1108*, *1114*
  for peripheral nerves, *443*
  Frazier's, *730*, *779*
  Halsted's, 602
  Richardson's appendiceal, *1114*
  Volkmann's, 601
Retrograde intussusception, 1062
Retromammary abscess, *889*, 892
Retroperitoneal hernia, 1204
Retropharyngeal abscess, 830
Retrorectal abscess, 1208
Retrosternal goiter, 475
Reverdin's needle, 603
Reverdin-Halsted method of skin-grafting, 615
Revulsion, 516
Rhabdomyoma, 191, **192**
Rhagades of face, 796
Rheumatic arthritis, 335
  torticollis, 382
Rheumatism, chronic, of spine, 340
  muscular, 382
Rheumatoid arthritis, 340
Rhinopharyngitis mutilans, 180
Rhinophyma, 463, **798**
Rhinoplasty, 619
Rhinoscleroma, **175**, 797
Rhizanesthesia, 561
Rhizopoda, 65
Rhizotomy, 781
  extradural, 782
  Förster's method, 781
Rhytidectomy, *791*
Ribbon stools in stricture of rectum and anus, 1217
Rib-props, Babcock's, *927*
Rib-spreader, Babcock's, *927*
Ribs, bicipital, 847
  cervical, 108, **846**
    paralysis of brachial plexus from, 448
    treatment, 848
  defects, **872**, 873
  fracture, 277
  osteomyelitis, 882
  regeneration, after costectomy, 920
  resection, with costectomy, 920
  sarcoma, 886
  suppurative osteitis, 882
  tuberculosis, 882
Rice-bodies in joints, 332, **335**
Richardson, 601
Richardson's appendiceal retractor, *1114*
Richter's hernia, 1167
Rickets, 223
  adolescent, 224
  annular, 225
  predisposing to fractures, 258
  scurvy, 224
  skull in, 683
Ricketts, 61
Rickettsia, 61
Rickety rosary, 223
Rider's bone, 190, **383**
  leg, 381
Riedel's disease, 476
  lobe, 1121
Riggs' disease, 819
Rigidity, decerebrate, 690
Rigor, 22
Ring fracture of base of skull, 677
Ringer's solution for wet or moist dressing, 50
  to stimulate arrested heart, 947

Rinné's test, 734
Ritter, 648
Rivinus' ducts, 825
Robbins and Seabury, 169
Roberts, 295
Robertson and Ingham, 775
Robson, 1030
Robson's point, 954
Rocky Mountain fever, wood tick in, 61
Rodent ulcer, 214, **471**
  of face, 802
Rodman, 1009, 1046
Rodman's incision in breast cancer, *905*
Roentgen diagnosis of abdominal disease, 956
  examination in fractures, 262
  findings in gastric ulcer, 1037
  rays in acne, 517
    burn from, 74
    dermatitis from, 67
    in cancer, 218
    in hyperthyroidism, 517
    in hypertrophy of prostate, 517
      of thymus, 517
    in inflammation, 24
    in leukemia, 517
    in splenomegaly, 517
    in sycosis, 517
    in tuberculosis, 517
    paresthesia of jaws and neck, 850
  study of genito-urinary organs, 1225
Roentgenization, 517
Roentgenography of lung, 923
    in malignant disease, 936
    lipiodol in, 923
Roger, 923
Roller bandage, **520**, 522
    double, 520
    single, 520
Romig, 55
Rongeurs, 598
  Cushing's, 681
  Dahlgren's, *706*
  small, *706*
Rosary, rickety, 223
Rose position, *835*
Rosenow, 1006, 1135
Rosenthal, 923, 1120
Ross and Dudgeon, 979
Rossbach's gastroxynsis, 1033
Rotation of skin flaps, Indian method, 613
  tests of Bárány, 694
Rotz, 172
Round ligament, hydrocele, 1282
    varicocele, 414
Round-cell infiltration, 20, 21
  sarcoma, 199
Round-worm, 61
Roussy, 490
Roux, 922, 1009
Roux's gastro-enterostomy *en* Y, *1044*, 1045
  operation for cancer of esophagus, 871
Rovsing's operation, 1048
Rowntree-Rosenthal dye-elimination test, 1120
Royle, 783
Rubefaction, 516
Rugby knee, 321
Rumination, 1033
Run around, 473
Rupture, definition, 1165
  infraclavicular, of brachial plexus, 446
  of aorta, spontaneous, 950
  of bladder, 961, **1250**, 1251
    in fracture of pelvis, 302
  of cruciate ligaments, 375
  of esophagus, 863
  of extensor tendon, flexion of terminal phalanx from, 366
  of gall-bladder, 1134
  of internal lateral ligament in fracture of fibula, 324
  of interosseous ligament in fracture of fibula, 324
  of kidney, 961
  of liver, 961
  of muscle, 381
  of penis, 1278
  of plantaris, 1304
  of right biceps muscle from muscular action, *382*
Rupture of spleen, 961
  of stomach, 1001
  of tendons, treatment, 386
  of trachea, 874
  of urethra, 1259
    in fracture of pelvis, 302
  supraclavicular, of brachial plexus, 446
Rutherford-Morison, 138
Rydygier, 1045
Rydygier's operation for movable spleen, 1158

Saber-tibia, 238
Sabowa, 148
Saccharomycosis hominis, 176
Sacculated aneurysm, **397**, 398
Sacless cecal hernia, 1182
Sacral anesthesia, 575
    anterior, 575
    posterior, 576
  anus, formation of, in rectal carcinoma, 1220
  hygroma, 757
  operation for carcinoma of rectum, 1220
  plexus, injuries, 457
Sacrococcygeal abscess, 758
  dermoids, 757
  fistulæ, congenital, 758
  growths, 756
  lipoma, congenital, 757
  meningocele, 756
  sinuses, congenital, 758
  teratoma, 757
  tumors, 757
Sacro-iliac joint, tuberculosis, 772
Sacrolumbar hypertrichosis, 757
Sacrum, fracture, 303
Saddle-nose, correction, *797*
  from submucous resection, *791*
  syphilitic, 796, *797*
Saddle-ulcer, 1006
Sagittal sinus thrombosis, 712
Sailor's knot, 607
Saint Andrew's cross, 525
Sal alembroth as antiseptic, 135
Salicylic solution, Ball's, 137
Saline, physiologic, with epinephrin, to stimulate arrested heart, 947
Salivary duct, inflammation, 825
  fistula, 827
  glands, 825
    anatomy, 825
    congenital anomalies, 825
    traumatism, 825
    tumors, 829
  stones, 827
Salpingitis, appendicitis and, differentiation, 1103
  gonorrheal, treatment, 1267
Salt solution for wet and moist dressing, 50
Samway's tourniquet, 82
Sand tumors, 201
Sandrock's test for impending gangrene, 94
Sanford, 171
Sanious pus, 26
Santy, 117
Saphenous peritoneal anastomosis for cirrhosis of liver, 1127
  phlebitis, 412
  varix, *1197*
    femoral hernia and, differentiation, 1196
    inguinal hernia and, differentiation, 1183
Sappey's accessory portal system, 1126
Sarcoid, 469
  infiltration of face, *795*
  multiple, of Boeck 469
  of Darier-Roussy, 470
  Spiegler-Fendt, 470
Sarcoma, 197
  alveolar, 199
  clinical features, 198
  comparative pathology, 199
  cutis, 470
    local non-pigmented, 470
  deciduocellulare, 215
  Ewing's, 249
    differential diagnosis, 254
Sarcoma, Ewing's, onion-layer appearance, **251**, 254
    giant-cell, 252
    idiopathic multiple pigmented, of Kaposi, 470
    melanotic, 200, **470**
    multiple hemorrhagic, 470
      of skin, 175
    of anus and rectum, 1221
    of bladder, 1258
    of bones, 244
      classification, 245
      secondary, 254
    of brain, 717
    of breast, 897
    of bursæ, 390
    of chest, 885
    of face, 801
    of intestine, 1085
    of Kaposi, treatment, 804
    of kidney, 1241
    of liver, 1128
    of lung, 936
    of lymph-nodes, 428
    of muscle, 384
    of neck, 858
    of pancreas, 1155
    of parotid, 829
    of peritoneum, 996
    of pituitary, 496
    of pleura, 918
      secondary, 918
    of ribs, 886
    of scalp, 669
    of skull, 685
    of sternum, 886
    of stomach, 1035
    of tendon-sheaths, 386
    of testis, 1286
    of thyroid gland, 485
    of tonsils, 832
    of upper jaw, 816
    osteogenic, 245. See also *Osteogenic sarcoma*.
    osteoid, 201
    periosteal, 245
    perithelial, 201
    plexiform, 201
    round-cell, 199
    spindle-cell, 200
    subcutaneous, of face, 801
    varieties, 197
Sarcomatosis, 198
Sarcomatous warts, cutaneous soft, 801
Sarcosis, miliary, 198
Sarcosporidia, 65
Satterlee, 598
Saturday-night palsy, 450
Sauerbruch, 920, 937, 941, 942
Sauerbruch's cabinet, 878
Sauvé and Tinel, 783
Saw, 598
  Charrier's, 598, *599*
  Engel's plaster-of-Paris, *530*
  flexible, 599
  Gigli's wire, *705*
Sawyer, 783
Sayre's dressing in fracture of clavicle, 281
Scabbard trachea, 477
Scalds, 66
  of epiglottis, 70
  of glottis, 70
  of larynx, 837
  of pharynx, 70
  of tongue, 70
  of trachea, 837
Scalp, 665
  adenoma, 668
  avulsion, 666
  boils, 667
  carbuncles, 667
  cellulitis, 668
  cirsoid aneurysm, 669
  dermoid cysts, 668
  erysipelas, 668
  furuncle, 668
  hemorrhage from, control, 705
  infections, 667
  injuries, subcutaneous, 665
  molluscum fibrosum, 669
  pachydermatocele, 669
  plexiform neuroma, 669
  pustules, 668

Scalp, sarcoma, 669
sebaceous cysts, 668
serous cysts, 668
subaponeurotic infections, 668
traumatic aneurysm, 669
von Recklinghausen's disease, 669
wen, 668
wounds, 666
Scalpels, 595
Scannell, 258
Scannell's apparatus for blood-transfusion, 93
Scaphoid bone, fracture, 298
carpal, dislocation, 362
Köhler's disease, 240
tarsal, epiphysitis, 239
Scapula alata, 353, 448, **1289**, 1290
angel-wing deformity, 1289
congenital elevation, 1289
dislocation, 353. See also *Dislocations of shoulder.*
fracture, 281
anatomic neck, 282
body, 281
surgical neck, 281
winged, 353, 448, **1289**
Scar. See *Cicatrix.*
Scarpa's trigone, ligation of femoral artery in, 637
Schaefer's guide and dural protector, *705*
method of artificial respiration, 501
wire saw-carrier, 599
Schantz, 513
Schaudinn and Hoffman, 161
Schede's operation for varicose veins, 416
thoracoplasty, 922
Schiff, 514, 948
Schimmelbusch's disease, 893, **896**
Schistosoma, 62
hæmatobium, 63
japonica, 63
mansoni, 63
Schistosomiasis, 62
genito-urinary, 63
intestinal, 63
Schistosomum hæmatobium, 62
Schlaepfer, 934
Schlange, 1250
Schlatter, 240, 1045
Schlatter's disease, 240, **321**
Schleich's solutions, 557
Schlesinger, 775
Schlesinger's classification of stomachs according to tone, *1025*
Schlösser's treatment of trigeminal neuralgia, 728
Schmidt, 1154
Schrötter, 841
Schüller, 782
Schwab and Allison, 783
Sciatic artery, ligation, 636
dislocation of hip, 368
hernia, 1204
nerve, injuries, 457
neuralgia, 435
Sciatica, 435
Lasègue's sign, 435
Scirrhosis, 21
Scirrhous carcinoma, 297
atrophic, of breast, 903
of breast, 899, *900*, *901*
of rectum, 1218
of thyroid gland, 485
withering, of breast, 908
Scirrhus, atrophic, 208
withering, 208
Scissors, Mayo dissecting, *27*, *576*
Sclavo's anti-anthrax serum, 153
Sclerosing solutions in varicose veins, 415
Scoliosis, 767
alterations of thorax in, *768*
of thoracic region, 873
postural, 768
static, 768
Scoliotic pelvis, 768
Scoop, gall-stone, *1143*
Scorbutic ulcer, 31
Scorbutus, 224
Scorpions, bites of, 60
Screw, oral, for jaws, *807*
worm, diseases produced by, 59
Scrofula, 159
Scrofuloderma, 467
Scrotal erysipelas, 144
hernia, 1166, *1170*, **1180**, *1184*, *1185*
hypospadias, 1278
Scrotum, epithelioma, 1287
lymph-, 187, **421**
tumors, 1287
Scudder, 816
Sculler's sprain, 362, 381
Scultetus bandage, 528
Scurvy, infantile, 224
rickets, 224
Seabury and Robbins, 169
Seat-worm, 62
Sebaceous cancer, 214
cysts, 220, **468**
of face, 801
of neck, 857
of scalp, 668
glands, retention cysts, 468
horns, 205, 798
tumors of chest, 884
Seborrheic patch, 462
Secretory neuroses of stomach, 1033
Sedative solutions for wounds, 50
Sedillot, 1045
Seelig and Tuholske, 1198
Sella turcica, 490
Sellheim, 577
Semilunar bone, fracture, 299
malacia, 240
of wrist, dislocation, 362
cartilage, internal, subluxation, 375
Seminal vesicles, calculus, 1277
diseases, 1276
excision, 1277
incision, 1277
inflammation, 1276
tuberculosis, 1277
vesiculitis, gonorrheal, chronic, 1265
treatment, 1264
Seminoma, 1286
Senile appendicitis, *1096*
atrophy of skull, 683
fracture, 257
gangrene, **101**, **102**
necrosis, 230
osteoporosis, 226
Senn, 1090
Sensation, epicritic, 433
joint, 429
pain, 429
protopathic, 433
sympathetic, 429
Sense, epicritic, 429
kinesthetic, 429
pressure, 429
protopathic, 429
tactile, 429
Sensibility, deep, 429
Sensory nerves, physiology, 429
neuroses of stomach, 1033
Sentinel pile, 1211
Sepsis, 125
postoperative treatment, 591
Septic abdominal section, postoperative treatment, 589
arteritis, 391
arthritis of wrist, 1299
emboli causing lung abscess, 928
meningitis, treatment, 689
pus, 26, **27**
pylephlebitis, 95
wound, 36
Septicemia, **126**, 127
anthrax, 152
streptococcus, 143
Sequence anesthesia, 545
Sequestration, 100
dermoids, 220
Sequestrum, **22**, 100
forceps, 598
Serocystic disease of breast, 897
Serohemorrhagic infection, 125
Seropus, 26
Serothorax, 912
Serous arthritis, 21
ascites, 994
bursitis, 21
distention of bursæ, **21**
exudate, 20
meningitis, 774
peritonitis, 21
Serous pleurisy, 21
Serratus muscle, paralysis, 384
Serrefins, 600
Serrenœud, 596
Serum, antitetanic, in burns, 70
pus-, 26
Sesamoid of great toe, fracture, 328
Seton, 516
Seventh cranial nerve, lesions, 731
Shears, heavy plaster cutting, *550*
Shedding of nails, 473
Shekelton's aneurysm, 395
Shellac-stones in stomach, 1003
Sherman's plates, 270
Shock, 112
and anesthetics, 115
and hemorrhage, 115
anesthesia in, 539
cerebral, 700
Crile's theory, 113
exciting causes, 114
from burns, treatment, 69
Henderson's theory, 113
in chest wounds, treatment, 879
McKesson's rule in, 115
pleural, 933
postoperative treatment, **589**, 591
predisposing causes, 114
primary, 112
protein, 22
secondary, 112
surgical, 112
Shoemaker, 1090
Shoulder, snapping, 358
spica bandage, 524
Sprengel's, 1289
Shoulder-blade, dislocation, 353. See also *Dislocations of shoulder.*
fracture, 281
Shoulder-drop, 852
Shoulder-girdle, osteogenic sarcoma, 246
Shoulder-joint, amputation, 651. See also *Amputation of shoulder.*
arthrotomy, 343, **345**
contusion, 358
fracture, optimum position for ankylosis, 264
sprain, 358
Shrapnel wounds of chest, 879
Shütz and Löffler, 172
Sialadenitis, 825
Sialodochitis, 825
Sialolithiasis, 827
Sialorrhea in pancreatic disease, 1150
Sibson's sign in aneurysm, 400
Sicard, 416, 509, 747
Sicard and Desmarest, 783
Sicard and Forestier, 923
Sickness, sleeping, 62
Sigmoid, adhesions constricting, 1068
carcinoma, *1083*
colostomy, 1090
resection, *1093*
sliding hernia, 1182
stricture, 1216
Sign, Battle's, 37
in fracture of base of skull, 678
Bryant's, in dislocation of scapula, 354
Callaway's, in dislocation of scapula, 354
Chvostek's, in gastric tetany, 1032
Dalrymple's, in exophthalmic goiter, 480
Dawbarn's, in subdeltoid bursitis, 389
Dugas', in dislocation of scapula, 354
Erb's, in gastric tetany, 1032
Froment's, of ulnar nerve paralysis, 455
Hoffman's, in gastric tetany, 1032
Joffroy's, in exophthalmic goiter, 480
Lasègue's, in sciatica, 435
Ludloff's, in fracture of neck of femur, 306
Möbius', in exophthalmic goiter, 480
Oliver's, in aneurysm, 400
Sibson's, in aneurysm, 400
Stellwag's, in exophthalmic goiter, 480
Tinel's, in nerve regeneration, **433**, 445
Trousseau's, in gastric tetany, 1032

Sign, von Graefe's, in exophthalmic goiter, 480
Signorini's tourniquet, 82
Silicate bandage, 531
Silver, antiseptic properties, 134
citrate, 136
clips, 84
lactate, 136
nitrate, 136
Silver-fork deformity, 294
Silver-protein, mild, 136
strong, 137
Silvester's method of artificial respiration, 500
Silvestri, 1045
Silvol, 136
Simple fracture, 257
Simpson, 86, 533
Sims, 134
Sims' position, *1209*
Sinapism, 516
Sinclair's glue, 267
Sinus, 33
acute, treatment, 34
disease, trigeminal neuralgia and, differentiation, 727
longitudinal thrombosis of, 712
of neck, lateral, 845
median, 845
pericranii, 671
phlebitis, 413
pilonidal, 758
sagittal, thrombosis of, 712
subacute, treatment, 34
thrombosis, cavernous, 712
thyroglossal, 845
transverse (lateral), thrombosis of, 712
umbilical, 958
Sinus-phlebitis, cerebral, 711
Sinuses, cerebral, hemorrhage from, control, 706
infective thrombosis, 711
venous, injury to, 707
sacrococcygeal, congenital, 758
Sinusitis, 807
Siphonaptera, diseases produced by, 59
Sippy treatment in gastric ulcer, 1008
Sistrunk's operation for elephantiasis, 422
Six-tailed bandage, 528
Sixth cranial nerve, lesions, 730
Skeletal traction in fractures, 268
Skey's amputation of foot, 655
Skin, anatomy, 460
basal-cell cancer, 471
treatment, 472
black and blue, 37
blastomycosis, 468
cancer, 210
cancroid, 471
changes in cancer of breast, 900
cleavage, lines, *608*
congenital anomalies, 460
defects in, closure, by flaps, 610
by sliding flaps of adjacent tissue, *607*
by stretching and sliding, 608
relaxing incisions, 609
plastic closure, *609*
diseases, 460
edema, 461
effect of spinal anesthesia upon, 564
flaps, 610
compound, 610
direct transference, 610
double-faced, 610
indirect transference, 610
island, 610
lined, 610
rotation of, Indian method, 613
sliding of, French method, 612
transfer of, from distant part, 613
Italian method, 613
tagliacotian method, 613
with vascular pedicle only, 613
tube grafts, 611
glossy, 432
in elephantiasis, 461
in myxedema, 461
incisions for cancer of breast, *905*, 908
irritation of, from caterpillars, 59
from Diptera, 59
from flies, 59
Skin, lines of cleavage, 460
lymphangioma, 801
melanoma, 470
multiple sarcoma, 175
of patient, preoperative treatment, 586
outer layer, wounds involving, 38
paraffinoma, 461
pigmentation, 461
preoperative sterilization, for abdominal operations with peritonitis or intestinal obstruction, 588
progressive gangrenous infection, 466
pustular lesions, roentgen rays in, 517
rat, 798
sarcoma, 470
slight irregularities, treatment, 55
spontaneous hemorrhage into, 460
sporotrichosis, 468
Staphylococcus pyogenes in, 141
Streptococcus pyogenes in, 143
tattooing, 461
traction in fractures, 266
tuberculosis, 467
Skin-grafting, 614
cuticle grafts, 615
epidermal grafts, 617
Esser's method, 617
Mangolte's method, 615
methods, 615
of amputation stumps, 644
Ollier-Thiersch method, 617
pinch grafts, 615
preparation of surface to be grafted, 614
Reverdin-Halsted method, 615
Thiersch's method, 617
Wolfe-Krause method, 617
Wolfe's method, 617
Skodaic resonance in purulent pleurisy, 915
Skull, 669
brachycephalic, 669
chloroma, 686
classification, 669
congenital anomalies, 670
defects, congenital, 665
operations for closure, 686
deformation, during labor, 664
dermoid cysts, 671
diseases, 681
dolicocephalic, 669
echinococcus cysts, 684
enlargement, due to excess of cerebrospinal fluid, 694
exostoses, 684
form, 669
fractures, 671. See also *Fractures of skull*.
giant-cell tumors, 685
hypsicephalic, 669
in rachitis, 683
in rickets, 683
incomplete ossification, 665
injuries, complications of, 708
congenital, 664
during labor, 664
in utero, 664
mesocephalic, 669
myeloma, 686
operations on, coronal incision, *704*
orthocephalic, 669
osteogenic sarcoma, 246
osteoma, 684
osteomalacia, 683
osteomyelitis, 681
osteophytes, 684
osteosarcoma, 686
Paget's disease, 684
pathologic types, 669
penetration, by automobile bolt, *700*, *701*
platycephalic, 669
sarcoma, 685
senile atrophy, 683
sutures, separation, 665
syphilis, 682
tuberculosis, 682
tumors, 684
ventricular cyst, 671
Sleeping sickness, 62
Sliding hernia, 1167, **1182**
of sigmoid, 1182
skin-flaps, French method, 612
Sling, 530
for arm, *529*
Slough, 100
Sloughing, 100
in gunshot wounds of face, 792
Smith-Peterson incision for approach to hip, 371
Smith's disarticulation of knee-joint, 657
elliptical amputation of leg, *646*
fracture, 295
modified circular amputation of leg, *646*
operation for cleft-palate, 787
racquet amputation of leg, *646*
treatment of dislocation of scapula, 357
Smoker's patch, **209**, 821
Snake bite, 56
venoms, **56**, 57
hemorrhagin of, 58
neurotoxin of, 57
Snap-finger, 1296
Snapped wrist, 298
Snapping hip, 1300
shoulder, 358
Snares, 596
Snow-ball crunching in osteo-arthritis, 341
Snow-blindness, 73
Soap liniment, 140
soft, 140
suppositories, 505
Soap-bubble appearance in giant-cell tumor of bone, 254
Soap-suds enema, 504
Sodium hypochlorite solution, 134
oxymercury orthonitrophenolate as antiseptic, 135
Soft chancre, 168
Softening of bones, 226
diffuse, 237
of nails, 473
secondary, in arteriosclerosis, 391
Solargentum, 136
Solar-plexus blow, 875
Solitary abscess of liver, 1122
Soluble glass bandage, 531
Somnoform anesthesia, 552
Sore, annamite, 179
cachar, 179
healing, 29
Kandahar, 178
Lahore, 178
Mozambique, 179
naga, 179
Oriental, 178
Veldt, 466
Sound, Gouley's, *1268*
introduced into bladder, *1273*
urethral, *1268*
introduction, *1270*, *1271*
Van Buren's, *1268*
Sounding for vesical calculus, 1253
Southey's capillary tubes for ascites, 994
Spanish windlass, 81
Sparganum mansoni in breast, 896
Spasm, facial, 733
histrionic, 733
of esophagus, 865
of eyelid, 734
of facial muscles, 733
Spasmodic flat-foot, 1307
stricture of rectum, 1216
of urethra, 1267
torticollis, 848
Spastic muscles, nerves supplying, alcoholic injection, 783
talipes, 1308
Spasticity, cerebral, peripheral operations to relieve, 783
Specific urethritis, 1260
Specula, 602
Speculum, Martin's rectal, *1210*
Spence's amputation of shoulder, 652
Spermatic cord, diffuse hydrocele, 1282
encysted hydrocele, 1282
infantile hydrocele, 1283
torsion, 1281
Spermatocele, 220, **1281**
Spermatocystitis, 1276
Sphacelation, 100
Sphacelus, 22, 100

Spica bandage, 522
of groin, 525
of shoulder, 524
Spider, bites of, 60,
cancer, 194
of face, 799
Spiegler-Fendt sarcoid, 470
Spiller and Frazier, 729, 733
Spina bifida, 747
anterior, 751
Babcock's operation, *753*, *754*, 755, 756, *757*, *758*
occulta, 750
ventosa, *237*
syphilitic, 1300
Spinal anesthesia, 533, **561**
abducens palsy after, 574
advantages, 573
associated anesthesia, 574
Babcock's light solution, 565
bradycardia of, *563*
clinical symptoms, 564
contraindications, 572
effect of, upon blood-pressure, 561, *562*, *563*
upon gastro-intestinal tract, 564
upon kidney, 564
upon respiration, 563
upon skin, 564
upon uterus, 564
equipment, 568
fall in blood-pressure during, 572
gravity localization, Babcock's method, 566
Barker's method, 577, *568*
headache after, 573
incontinence or spasm of vesical or urinary sphincters after, 574
injection, 570
localization of spinal interspaces, 569, *570*
marking point for introduction of needle, *571*
morbidity, 573
mortality, 574
necessary precautions, 574
physiology, 561
position, 569
secondary palsy after, 574
solution, 565
technic, 568
unconsciousness during, 571
block, Ayer's test, 743
cord, 738. See also *Spine.*
circulation, 741
concussion, 759
lesions, partial, 743
total transverse, 744
traumatic injury, 759
curvature, 767
lateral, 767
diagnostic tests, 744
headache, 738
hemorrhage, 766
extramedullary, 766
intramedullary, 767
lamina, fracture, 763
localization, 738
nerve-roots, 739
spinous processes, 739
manometer, *739*
Langdon's, *739*
meninges, inflammation, 773
meningitis, 773
nerve-roots, localization, 739
nerves of abdominal wall, 953
neurasthenia, traumatic, 759
osteitis, 766
puncture, danger, from foraminal hernia when intracerebral pressure is increased, *698*
in brain tumors, 721
radiography, 746
reflexes, 741
cervical region, 742
defence, 741
lower dorsal region, 743
rectal function, 742
sexual, 742
sympathetic, 741
upper lumbar region, 743
vesical symptoms, 741
Spindle-cell sarcoma, 200
Spine, 738. See also *Spinal cord.*
Spine, abscess, 769
cold, 772
articular processes, dislocation, 759
cholesteatoma, *775*
chronic rheumatism, 340
congenital anomalies, 747
diseases, 767
dislocation, 752
atlas on epistropheus, 761
occiput on atlas, 761
endothelioma, 775
foreign bodies in, removal, 780
fracture-dislocation, 764
gumma, 778
operations on, 779
osteo-arthritis, 340
perithelioma, 775
psammoma, 775
railway, 759
sprains, 759
transverse process, fracture, 763
tuberculoma, 778
tuberculosis, 769. See also *Pott's disease.*
tumors, 774. See also *Tumors of spine.*
twists, 759
Spinocell cancer, 210
Spinofacial anastomosis, 733
Spinous processes, fracture, 763
localization, 739
Spiral bandage, 521
fracture, 256
reverse bandage, 521
Spirochæta morsus muris, 168
Spirochætæ, infection by, 160
Spironemata, infection by, 160
Spitzy, 783
Splanchnic anesthesia, anterior, 578
posterior, 578
Splanchnoptosis, 1167
Splay-foot, 1304
Spleen, 1157
abscess, 1159
congenital anomalies, 1157
cysts, 1164
diseased, effect of removal, 1157
enlargement, 1159
floating, 1158
functions, 1157
Gaucher's, 1163
hard-baked, 425
infarction, 1159
injuries, 1158
movable, 1158
Rydygier's operation, 1158
normal, effect of removal, 1157
prolapse, 1159
ptosed, 1158
rupture, 961
syphilis, 1160
tuberculosis, 1160
tumors, 1164
wandering, 1158
Splenectomy, *1162*, *1163*, 1164
for ascites, 995
for cirrhosis of liver, 1127
for Gaucher's disease, 1163
for hypertrophic biliary cirrhosis, 1127
for pernicious anemia, 1161
for splenomyelogenous leukemia, 1162
Splenic anemia, 1160
chronic, of children, 1160
hematemesis in, 1024
fever of animals, 152
pericolic adhesion, 990
Splenomegaly, 1159
primary, 1161
roentgen rays in, 517
Splenomyelogenous leukemia, 1162
Splenopexy, 1158
Splenoptosis, 1158
Splint, 531
angular, 531
internal, *298*
anterior angular, 531
banjo-, *299*
Bavarian, 531
Bond's, *295*
Buerki's cock-up, *451*
Cabot's posterior wire leg, *267*
coaptation, 531
Splint, cock-up, 265
improvised, *296*
Denman-Jones humerus, *287*
Dupuytren's, 531
emergency, 531
flexible coaptation, 531
Gooch's, 531
Hammond wire, 277, **532**
Hodgen's, *267*
internal angular, 531
Jones' crab cock-up, *297*
humerus, 287
short cock-up, *299*
Levis, 532
Liston's straight, 531
molded, 531
removable, 531
provisional, 531
simple straight, 531
Stromeyer's, 532
Thomas' half-ring leg-extension, *266*
lower-extremity, *266*
upper-extremity, *266*
Travois, 531
wire, 532
Splinter forceps, 601
fractures, 255
Splitting of nail, 473
Spondylitis rhizomelica, 340
traumatic, 766
Spondylolisthesis, 766
overlapping ribs in, 844
Spongy aneurysm, 469
osteoma, 242
Spontaneous fracture, 257
hemorrhage into skin, 460
Spoon-nails, 473
Sporothrix shenkii, 178
Sporotrichosis, 178
of skin, 468
Sporozoa, 65
Sprain, 346
dancer's, 381
jumper's, 381
of elbow, 362
of hip, 371
of shoulder-joint, 358
of spine, 759
sculler's, 362, 381
Sprained ankle, 331
Spreading ulcer, 29
Sprengel's deformity, 1289
incision for approach to hip, 371
shoulder, 1289
Spring-finger, 1296
Springing hip, 1300
Sprinter's strain, 381
Sprue, 819
tropical, 819
Spurway, 225
Squamous epithelioma, 206
of anus, 1218
Squamous-cell carcinoma, 210
epithelioma of nipple, 904
Square head, 683
knot, *606*, 607
Ssabanajew, 1045
Ssabanajew-Frank gastrostomy, 1047
St. Anthony's fire, 144
Stab wounds, 43
Staffordshire knot, 607
Stain, port-wine, 469
Stamm, 1045
Stamm's gastrostomy, 1047
Stammering bladder, 1248
Stange's test, 585
in anesthesia, 536
Stanley, 621
Staphylococcus albus meningitis, 688
peritonitis, 976
aureus meningitis, 688
peritonitis, 976
bacteremia, 142
epidermidis albus, 141
osteomyelitis, *232*
pyogenes, 141
albus, 141
aureus, 141
citreus, 141
in bone, 141
in mucous and serous surfaces, 142
in skin, 141
infection, 141, **143**
treatment, 142

Staphylococcus vaccine, 141
Staphylolysin, 141
Starch bandage, 531
Stasis, duodenal, chronic, 1027
  intestinal, chronic, 1068
  lymph-, 420
Static esophagitis, 868
  flat-foot, 1306
  scoliosis, 768
Status epilepticus, 118
  lymphaticus, 489
  thymicolymphaticus, 489
Stave of thumb, 299
Stay knot, *606*, **607**, 624
Steam cauterization, 597
  sterilization, 130
Steam-pressure sterilizers, 131
Stearate of zinc, inhalation of, 924
Steatoma, 468
Steatorrhea in pancreatic disease, 1150
Steel, 510
Steer-horn stomach, *999*
Steindler, 387
Steinmann's transfixion pin, 268
Stellate fractures, 255
Stellwag's sign in exophthalmic goiter, 480
Steno's duct, 825
Stenosis, congenital, of esophagus, 861
  intestinal, 1069
    congenital, 1054
    in tuberculosis, 1069
  of esophagus, 867
  of larynx and trachea, 837
  of meatus urinarius, 1277
  of pharynx, 830
  of pylorus, 1026
    hypertrophic, 1031
      congenital, 999
  of rectum, 1216
Steppage gait, 458
Stercoraceous vomiting, 1059
  in strangulated hernia, 1174
Sterile gown, 582
  pus, 26
Sterilization, 128
  of hands, 581
    Furbringer's method, 581
  steam, 130
  thermal, 129
Sterilizers, formaldehyd, 136
  steam-pressure, 131
Sternberg, 146
Sternodymus, 873
Sternomastoid muscle, gumma, 856
Sternopagus, 873
Sternum, bifid ensiform, 872
  defects, 872
  fissure, 872
  fracture, 279
  osteomyelitis, 882
  sarcoma, 886
  suppurative osteitis, 882
  tuberculosis, 882
Stewart, 944, 1047
Stewart's incision in breast cancer, *905*
Stewart and Ballance, 733
Stiff bandage, 530
  neck, acute, 382
Stiffness of joint, 342
Still's disease, 341
Stille, 598
Stimson, 350, 352
Stimson's postural method of reducing backward dislocation of hip, **368**, 369
  treatment of dislocation of scapula, 355
Stimulating enema, 504
Stirrup, Chutro's, 269
  Finochetti, 269
  os calcis, 269
Stocking anesthesia, 433
Stöffel's method of suturing tendons, *385*
  operation for extensor paralysis of fingers, 387
    of wrist, 387
  to relieve cerebral spasticity, 783
Stoke, 950
Stokes, 178, 214, 340, 337, 338, 339, 389, 424, 467, 468, 471, 793, 795, 796, 803, 1285
Stomach, 998
Stomach, abscess, 1004
  adenoma, 1033
  angioma, *1034*
  arteries, points of ligation in gastrectomy, *1040*
  atony, 1025
  Balfour's operation, *1039*
  bezoar, 1003
  Billroth's operations, *1038*, *1048*
    modified, *1043*, *1050*
  Brandt's operation, 1049, 1051
  burns, 1002
    stricture following, 1003
  carcinoma, 1035, *1036*, *1037*
    conditions contraindicating excision, *1042*
    encephaloid, 1037
    extension, 1036
    hematemesis in, 1024
    leather-bottle stomach in, 1036
    medullary, 1037
    palliative operation, 1044
    partial gastrectomy for, 1043
    peptic ulcer and, differentiation, 1017
    perforated peptic ulcer and, differentiation, 1011
    secondary to gastric ulcer, 1012
    site, 1036
  cirrhosis, 1030
  Coffey's hammock-operation, 1048
  congenital anomalies, 999
  cow-horn, *1025*
  cysts, 1033
  dilatation, acute, 1024
    chronic, 1025
    gastric tetany in, 1031
  diverticulum, 1028
    with ulcer, *1028*
  division of, in partial gastrectomy, *1041*
  dumping, following gastro-enterostomy, 1022
  exploration, 1046
  fallen, 1027
  fish-hook, *999*, 1025
  fistula, 1004
  food-ball in, 1003
  foreign body in, 1003
    from adjacent structure, 1003
    Vienna treatment, 1004
  Frank's operation, 1047
  Fränkel-Babcock anastomosis, *1043*, *1049*
  functional disturbances, 1032
  gall-stones in, 1003
  Hahn's operation, 1047
  hair-ball in, 1003
  Heineke-Mikulicz operation, 1049
  hemorrhage from, 1023
    treatment, 89
  Hoffmeister-Finsterer operation, *1039*
  hour-glass, 1029
    with gastric ulcer, *1029*
  hypermotility, 1033
  hypertonic, *1025*
  hypertrophy, 1026
  hypotonic, *1025*
  inspection by gastroscopy, 999
    by gastrostomy-pyloroscopy, 999
  Kader's operation, 1047
  Kocher's operation, *1038*, *1050*
  Krönlein's operation, *1039*
  leather-bottle, 1030
    in carcinoma, 1036
  Loreta's operation, 1047
  lymphatic drainage, in relation to partial gastrectomy, 1042
  lymphoblastoma, 1035
  Mikulicz's operation, *1038*, 1046
  motor insufficiency, 1025
  Murphy button in, 1003
  myoma, 1033
  needles in, 1003
  neuroses, 1032
    motor, 1032
    secretory, 1033
    sensory, 1033
  operations, 1045
  orthotonic, *1025*
  perforations, *1002*
  phytobezoar, 1003
  polyadenoma, 1034
  polyposis, 1034, *1035*
  prolapse, 1072
    Reichel-Polya operation, *1030*, *1039*, 1051
    resection, coat-sleeve, 1052
      midgastric, 1052
    Roux's operation, 1044
    Rovsing's operation, 1048
    rupture, 1001
    sarcoma, 1035
    Schlesinger's classification according to tone, *1025*
    shellac-stones in, 1003
    steer-horn, *999*
    stricture of, following burns, 1003
    symptomatology, 998
    syphilis, 1032
    trichobezoar, 1003
    tuberculosis, 1032
    tumors, 1033
      benign, 1033
      malignant, 1035
    ulcer, *1005*, 1006. See also *Ulcer, gastric*.
      and diverticulum, *1028*
    volvulus, 1028
    von Hacker's operation, *1015*, 1051
    Witzel's operation, **1047**, 1048
    Wölfler operation, 1049
    wounds, 1001
      closed, from external violence, 1001
      from within, 1002
      perforating, 1001
Stomach-clamp forceps, Lenhartz's, for gastro-enterostomy, *1012*
Stomach-forceps, Doyen's, *1012*
Stomatitis, gangrenous, 110, **820**
  ulcerosa, 820
Stone bruise, 387
Stones in bile-ducts, 1149
    Courvoisier's law, 1149
  in bladder, 1252
  in kidney, 1228
  in ureter, 1244
  in urethra, 1259
  of seminal vesicles, 1277
  preputial, 1279
  prostatic, 1275
  umbilical, 959
  vein-, 411
Stools, pipe-stem, in stricture of rectum and anus, 1217
  ribbon, in stricture of rectum and anus, 1217
Stovain, local anesthesia by, 559
Stovarsol in syphilis, 165
Strahlenpilz, 170
Strain of muscle, 381
  sprinter's, 381
Strangulated hernia, *1171*, **1173**, *1174*, *1175*
    appendicitis and, differentiation, 1104
    fecal vomiting in, 1174
    herniotomy for, 1176
    intestinal stricture after, 1066
    postoperative obstruction, 1177
Strangulation, gangrene from, 105
  treatment, 38
Strapping ankle, *330*
Strauss, 1001
Strawberry birthmark, 469
  gall-bladder, 1135
Streptococcic meningitis, 688
Streptococcus bacteremia, 143
  erysipelatis, 144
  mucosa, 144
  peritonitis, 976
  pyogenes, 143
    in skin, 143
    infection, local, 144
  septicemia, 143
  viridans, 143, **144**
Streptothrix actinomyces, 170
Stretching of peripheral nerves, 430
Stricture, congenital, of urethra, 1258
  of anus, 1216
  of esophagus, 867
  of intestines, 1066
  of larynx and trachea, 837
  of meatus urinarius, 1277
  of rectum, 1206, **1216**
    inflammatory, 1217
    malignant, 1217
    organic, 1216

Stricture of rectum, pipe-stem stools in, 1217
proctectomy for, 1217
proctotomy for, 1217
ribbon stools in, 1217
spasmodic, 1216
traumatic, 1217
of sigmoid, 1216
of stomach following burns, 1003
of ureter, 1243
of urethra, 1237
cicatricial, 1268
complications, 1270
organic, 1268
spasmodic, 1267
Stridor, laryngeal, 489
Striped muscle, regeneration of, 26
Stripping, muscle, 386
Stromeyer, 1294
Stromeyer's splint, 532
Strong silver-protein, 137
Struma, 476
chromophobe, of Cushing, 495
lipomatodes aberrata renis, 203
pituitary, 493
simple, 479
Strumous dactylitis, 237
lip, 789
Strümpell-Marie, 767
Stumps, amputation, 643. See also *Amputation stumps.*
Stupes, turpentine, 516
Stupor, postoperative treatment, 589
Styloid process of ulna, fracture, 292
Styptics, 83
Subacromial bursitis, 389
Subaponeurotic hematoma, 665
infections of scalp, 668
Subarachnoid injection, 509
Subastragaloid dislocations, 379
Subclavian artery, digital compression, 80
ligation, 631
Subclavicular dislocation, 354
Subcoracoid dislocation, 354
Subcrural bursa, inflammation, 390
Subcutaneous abscess of anus and rectum, 1208
felon, 1297
infusion, 507
injections, 505
injuries of scalp, 665
sarcoma of face, 801
wounds, 36
Subcuticular felon, 1297
Subdeltoid bursitis, 389
Dawbarn's sign, 389
with calcification, *388*
Subdiaphragmatic cardiac massage, 502
Subdural injection, 509
Subglenoid dislocation, 354
Sublimate solution as wet or moist dressing for wounds, 50
Subluxation, 346
of elbow-joint, 361
of internal semilunar cartilage, 375
of lower jaw, 351
of penis, 1278
Submaxillary duct, foreign bodies in, 826
ganglion, destruction, 851
gland, anatomy, 825
Subpectoral abscess, 881
Subpericranial effusions, 666
Subperiosteal bone felon, 1298
fractures, 257
Subperitoneal lipoma, femoral hernia and, differentiation, 1197
Subphrenic abscess, 986, *988*
empyema and, differentiation, 915
extraperitoneal, 987
intraperitoneal, 986
liver abscess and, differentiation, 988
pleural effusions and, differentiation, 988
Subscapular abscess, 882
bursa, inflammation, 390
Subsynovial lipoma, 192
Subtalar amputation of foot, 656
dislocations, 379
Subtentorial craniotomy, *720*, *721*, *722*, *723*, *724*
Subtrochanteric osteotomy for congenital dislocation of hip, 373
Subungual callus, 474
clavis, 474
exostoses, 242, **474**
Sucking wounds of chest, 877
treatment, 880
Suctorial insects, diseases produced by, 60
Suffocating gases, effects of, 71
Suffusion of blood, 78
Sugar-ice liver, 995, **1127**
Suggillation in fractures, 261
of blood, 78
Sulfarsenol in syphilis, 165
Sulpharsphenamin in syphilis, 165
Sulphur granules, 170
Sun-rays appearance in osteogenic sarcoma, **248**, 253
Sunburn, 67, **73**
Superfluous hair, 462
Supporting bandage, postoperative, 592
Suppositories, evacuant, 505
glycerin, 505
soap, 505
Suppression of urine, 1224
Suppuration, 20, 22, **26**
of chest wall, 880
of peritonsillar tissues, 831
Suppurative gastritis, 1004
lymphadenitis, 938
osteitis of ribs and sternum, 882
pancreatitis, 1152
tenosynovitis, 1298
Supraclavicular rupture of brachial plexus, 446
Supracondyloid amputation of leg, 658
fracture, transverse, of humerus, 288
Supracoracoid dislocation, 354
Supracotyloid dislocation of hip, 367
Supramalleolar deformity, Volkmann's, 1304
Suprapubic lithotomy, 1254
prostatectomy, 1275
Suprarenal glands, accessory, 498
adenoma, 499
diseases, 498
hyperplasia, 498
hypoplasia, 498
neuroblastoma, 499
tumors, 499
rest in kidney, 499
Suprascapular abscess, 882
nerve, injuries, 449
Surgeon's knot, *606*
Surgery, anatomic era, 19
art of, 17
clinical, definition, 18
definition, 17
experimental, definition, 18
general, definition, 17
major, definition, 18
minor, definition, 18
operative, definition, 18
pathologic era, 19
physiologic era, 19
regional, definition, 18
science of, 17
special, definition, 18
Surgical anesthesia, 533
eras, 19
infections, acute, 141
chronic, 158
shock, 112
technic, 500
therapeutics, 500
Sustentaculum tali, fracture, 326
Sutton and Tinker, 584
Suture à distance, *440*
materials, intestinal, 1086
Sutures, 604
Albert's intestinal, 1087
anastomosis of intestines, 1090
bootlace intestinal, 1088
button, *604*
cobbler intestinal, 1088
combined relaxing and coapting, *604*
Connell's intestinal, 1089
continuous, *603*
Cushing's intestinal, 1087
Czerny's intestinal, 1086, *1087*
Dupuytren's intestinal, 1086
for shortening elongated colon, 1086
Gely's intestinal, 1088
Gould's intestinal, 1087
Sutures, Gussenbauer's intestinal, *1087*
Halsted's intestinal, *1085*, 1087
intermediate, coapting, *604*
interrupted, *603*
intestinal, *1085*, 1086
Lembert's intestinal, *1085*, 1086
mattress-, 604
of aorta, 950
of arteries, 950
technic, *411*
of divided nerve, 439
of heart, 948
of peritoneal surfaces, postoperative, 1086
of skull, separation, 665
of tendons, Stöffel's method, *385*
Wilms' method, *385*
of wounds, 41
delayed primary, 41
secondary, 41
purse-string, in appendectomy, *1111*
relaxing, *604*
removal, 592
Wölfler's intestinal, *1087*
Swallowing, tongue-, 820
Swathe, Lund, 529
Sweating, spina bifida, 748
Swelled head, 170
Swelling as symptom of inflammation, 22
cloudy, 21
in fractures, 261
of base of skull, 677
pseudo-white, 339
white, 335
Swetlow, 946
Swine fever, 61
Sycosis, roentgen rays in, 517
Syme's amputation of ankle, 656
operation for cancer of tongue, 824
for urethral stricture, 1269
Symmetrical gangrene, 107
Symond's tube, *871*
Sympathectomy, cervical, 947
Sympathetic nerve, cervical, lesions, 737
resection, 783
sensation, 429
Symphallangism, 1293
Syncope, 112
Syncytioma malignum, 215
of testes, 1286
Syndactylism, 1289, **1292**
Syndrome, Aran-Duchenne, 447
blue-sclera, 225
Brown-Séquard, 433, **744**, 776, 777
reversed, 778
Courvoisier's, in carcinoma of small intestine, 1081
Erb-Duchenne, 447
Fröhlich, 492, **495**
Froin's, 748
Gradenigo's, in brain abscess, 709
in meningitis, 688
Horner's, **737**, 742
Köhler's metatarsophalangeal, 328
Nonne's, 746
Pel-Ebstein, 426
polyglandular, *491*, 492
radicular, middle, 447
upper, 447
trephine, 721
Synovial membrane, inflammation, 329
pannus, 335
thecal felon, 1298
Synovitis, acute, 329
chronic, 331
syphilitic, 338
Syostosis of radius and ulna, 1290
Syphilides, 162
Syphilis, 161
Colles' law, 163
congenital, in infancy, treatment, 166
hereditary lesions, 163
innocentium, 161
of bones, 238
of chest wall, 883
of face, 796
lupus and, differentiation, 796
of finger, 1299
of intestines, tuberculosis and, differentiation, 1077
of jaw, 810
of joint, 338

Syphilis of lymph-gland of neck, 856
of parotid, 829
of rectum and anus, 1217
of skull, 682
of spleen, 1160
of stomach, 1032
of testes, 1285
of tongue, 822
of tonsils, 832
primary lesion, 161
Profeta's law, 163
secondary lesions, 161
tertiary lesions, 162
treatment, 165
Syphilitic arteritis, 392
arthralgia, 338
arthritis, 338
atheroma, 393
bursopathy of Vernieul, *389*
chondro-osteopolyarthritis, 339
dactylitis, 339
epididymitis, 1285
gumma of brain, 717
hydrarthrosis, 338
of knee, 339
laryngitis, 840
lymphangitis, 424
meningitis, 689
mesarteritis, 392
periarteritis, 393
polyarthritis, 338
pseudorheumatism, 338
saddle-nose, 796, *797*
spina ventosa, 1300
stricture of intestine, 1065
synovitis, 338
ulcer, 30, *467*
about knee, *163*
treatment, 33
Syphiloderm, 161
Syringe method of blood-transfusion, 92
Syringomyelitis, tumors of spine and, differentiation, 779
Syringomyelocele, 748, *749*
diagnosis, 752
prognosis, 753

T-BANDAGE, 526, 527
T-fracture of humerus, 288
T-shaped fracture of lower end of femur, 316
of shaft of femur, 312
Tabell,, 1047
Tabes, juvenile, 340
mesenterica, 425, **991**
Tabetic arthropathy, 340
Tache cérébrale in tuberculous meningitis, 690
Taches bleuâtres, 60
Tachycardia in acute appendicitis, 1100
Tack in bronchus, *924*
Tactile sensation, cortical representation, 690
in abdomen, 954
sense, 429
Tænia echinococcus, 64
solium, 64
Tagliacotian method of transfer of skin flaps, 613
Tail, complete, of spine, 758
incomplete, of spine, 758
Tailed bandages, 526
Tailor's ankle, 390
Tait's knot, 607
Talipes, 1307
acquired, 1308
calcaneovalgus, 1307
calcaneovarus, 1307
calcaneus, 1307
congenital, 1307, 1308
equinovalgus, 1307
equinovarus, 1307, 1308
equinus, 1307
paralytic, 1308
spastic, 1308
valgus, 1307
varus, 1307
Talking in operating room, 580
Talma operation for ascites, 994
for cirrhosis of liver, 1127
Talus, dislocation, 379
fracture, 327
Tampon, Mikulicz's, 52
Tamponade, heart, 944
pericardial, 944
Tannic acid for burns, 69
Tapeworms, 64
armed, 64
larvæ, in breast, 896
pork, 64
Tar cancer, 206
Tarantula, bites of, 60
Tarsal dislocation, transverse, 380
scaphoid, epiphysitis, 239
navicular, Köhler's disease, 240
Tarsometatarsal amputation of foot, 653
dislocation, 380
Tarsus, dislocation, 380
fracture, 327
Tattooing of skin, 461
Taxis in femoral hernia, 1198
of hernia, 1169
Taylor, 783
Teale's amputation, 641
gorget, *1369*
Tear-gas, effects of, 71
Technic, surgical, 500
Teeth, Fournier's, 163, *164*
Hutchinson's, 163, *811*
characteristics, *164*
odontoma, 205
Telangiectasis, 463
Telangiectatic angioma, 193, 194
lymphangioma, 197
of face, 800
Temporal artery, digital compression, 80
ligation, 630
Tenaculum, 599
forceps, 599
Tenderness in acute appendicitis, 1098
Tendinitis, 387
Tendo achillis, Anderson's method of lengthening, *385*
contracted, 1304
Tendo-calcaneus, contracted, 1304
Tendo-callus, 1296
Tendons, crepitus, 384
diseases, 384
dislocations, 386
extensor, of fingers, dislocation, 1297
inflammation, 387
operations on, 386
transplantation, 619
ossification, 242
rupture, treatment, 386
sheaths, inflammation, 384
tumors, 385
suture, Stöffel's method, *385*
Wilms' method, *385*
Tenesmus, 22
rectal, 1207
Tennis leg, 1304
Tenodesis, 386
Tenomyoplasty, 386
Tenoplasty, 386
Tenorrhaphy, *385*, 386
after-treatment, 386
Tenosynovitis, 384
purulent, 384
suppurative, 1298
Tenotomes, 595
Tenotomy, 386
after-treatment, 386
Tenth cranial nerve, lesions, 735
Teratoma, 220
of neck, 845
of testis, 1286
postanal, 758
sacrococcygeal, 757
Terebrant ulcers, 215
Tesla current, 518
Test, Ayer's, for spinal block, 745
Bárány's, 694
beer-, of gonorrhea, 1260
bitrochanteric, in fracture of base of neck of femur, 310
blood-urea, of kidney function, 1226
Cammidge, in pancreatic disease, 1151
carbohydrate, in hepatic disease, 1120
Chiene's, in fracture of neck of femur, 306
chromocystoscopy, of renal function, 1226
cryoscopy, of kidney function, 1226
electrical, to determine sensory conductivity of peripheral nerves, 436
Test, finger, in fracture of neck of femur, 306
for fixation of hip-joint in morbus coxarius, *336*
for hepatic disease, 1119
hydrostatic, for rupture of bladder, 1251
indigo-carmine, of renal function, 1225
MacLean's, of renal function, 1226
motor, to determine conductivity of peripheral nerves, 437
Nonne-Apelt, of cerebrospinal fluid, 746
Nonne's, of cerebrospinal fluid, 746
Pandy's, of cerebrospinal fluid, 746
phenolsulphonephthalein, of kidney function, 1226
phloridzin, of kidney function, 1226
Rinné's, 734
Rowntree-Rosenthal dye-elimination, 1120
Stange's, 585
in anesthesia, 536
tourniquet, in purpura hæmorrhagica, 1161
Trendelenburg's, for differentiating coxa vara and congenital dislocation of hip, 373
for varicose veins, 414
urea-concentration, of kidney function, 1226
urobilin, 1120
van den Bergh's, 1120
Weber's tuning-fork, 734
Wohlgemuth's, in pancreatic cysts, 1154
Testes, 1281
absence, 1281
adenoma, 1285
billiard-ball, *1285*
chorio-epithelioma, 1286
chorioma, 1286
cirrhosis, 1285
displacement, 1281
ectopia, 1281
embryoma, 1286
encysted hydrocele, 1284
fibroma, 1285
fungus, *1285*
gumma, *1285*
hydrocele, 1282
inflammation, 1284
leiomyoma, 1285
mixed tumors, 1286
retained, 1281
sarcoma, 1285, *1286*
syncytioma, 1286
syphilis, 1285
teratoma, 1286
transplantation, 621
tuberculosis, 1284
tumors, 1285, 1286
undescended, 1281
inguinal hernia and, differentiation, 1183
Testicular growths, inguinal hernia and, differentiation, 1184
Tetanolysin, 149
Tetanospasmin, 149
Tetanus, 149
cephalic, 150
facialis, 794
head, 150
hydrophobicus, 794
idiopathic, 149
neonatorum, 149
paralyticus, 794
prophylaxis, 150
puerperal, 149
traumatic, 149
treatment, 151
Tetany, gastric, 1031
accoucheur's hand in, 1031
Chvostek's sign, 1032
Erb's sign, 1032
Hoffman's sign, 1032
Trousseau's sign, 1032
Tetia, 167
Texas cattle fever, 60
Thecal felon, synovial, 1298
Thecitis, 384
Thenar muscles, paralysis, treatment, 387

Thenar space, abscess, 1299
Theobald, 275
Therapeutics, surgical, 500
Thermal sterilization, 129
Thermotherapy, 513
Thiersch, 942
Thiersch's method of skin-grafting, *616*, 617
on dry skull, *667*
solution, 137
Thigh, amputation of leg through, 658
guillotine amputation through, 648
transference of pedicled flap from, *615*
Third cranial nerve, lesions, 726
Thomas, 645, 892
Thomas' half-ring leg-extension splint, *266*
incision in recurrent dislocations of shoulder, 358
lower-extremity splint, *266*
tourniquet, 82
upper-extremity splint, *266*
Thomas-Warren breast incision, *890*
Thompson, 626
Thoracentesis, 918
pneumothorax complicating, 919
recurrence of fluid after, 918
Thoracic aorta, aneurysm, Babcock's operation, 409, *410*
treatment, 409
wounds, 950
duct, injuries, 850
wounds, 419
nerve, long, injuries, 448
operations, 918
vertebræ, lower, abscess of, 772
upper, abscess of, 772
wall, 872. See also *Chest wall*, 872
Thoracopagus, 873
Thoracoplasty, 922
Estlander's, 922
in bronchiectasis, 932
local, 941
plastic, 922
Schede's, 922
Thoracostomy, *917*
methods of expanding lung after, 921
trocar-tube method, 919
Thoracotomy, 918, 919
exploratory, *919*, *927*
major intercostal, 920
minor intercostal, 919
with rib resection, 920
Thorax. See *Chest*.
Thornburn, 766
Thornton's method of removing pinch graft with two safety-razor blades, *615*
Thread-worm, 62
Thrill, hydrated, in hydatid cysts of liver 1125
Throat, cut-, 849
Thrombectomy, 98
pulmonary, 98
Thrombo-angiitis obliterans, 105, 392
Thrombo-arteritis obliterans, 392
Thrombocytopenia in purpura hæmorrhagica, 1161
Thrombosis, 94
after appendicitis, 95
arterial, of extremities, 97
treatment, 46
etiology, 94
height of gangrene following, 94
in influenza, 94
in pneumonia, 94
in pulmonary tuberculosis, 94
infective, of cerebral sinuses, 711
mesenteric, 95
of cavernous sinus, 712
of femoral artery, gangrene from, *96*
of internal jugular vein, 96
of longitudinal sinus, 712
of sagittal sinus, 712
of transverse (lateral) sinus, 712
of veins, 411
postoperative, 95
venous, 99
Thrombotic hemorrhoids, 1212, *1213*
external, 412
Thrombus, 84
of facial vein, *412*
venous, 411
Thrush, 819
Thumb, abduction paralysis, treatment, 387
absence of, compound abdominal flap as substitute for, 620
transplantation of toe as substitute for, 620
amputation, 650
ascending spica bandage, *523*
dislocation, 364
backward, 364–366
forceps for appendectomy, *1108*
stave of, 299
terminal phalanx, comminuted fracture, 301
Thymic asthma, 489
death, 490
Thymol iodid, 138
Thymus, diseases, 489
duct, 845
enlargement, 489
hyperplasia of, asphyxia in, *489*
hypertrophy, roentgen rays in, 517
size, 489
Thyreoptosis, 475
Thyritis, 475
Thyroglossal cyst, 845
fistula, 845
sinus, 845
Thyroid artery, inferior, digital compression, 80
ligation of, 630
superior, Crile's method of incision, 629
ligation of, 629
crisis in exophthalmic goiter, 482
gland, adenocarcinoma, 484
adenoma, 483
carcinoma, 484
colloid adenoma, 483
congenital anomalies, 475
diseases, 475
excess of normal secretion, 479
fetal adenoma, 483
inflammation, 475
chronic, 476
injection, 486
insufficient activity, 477
ligation, 487
malignant adenoma, 484
tumors, 484
operations on, 485
accessory nerve injury complicating, 488
air embolism complicating, 488
auricular fibrillation complicating, 489
complications, 488
hemorrhage complicating, 488
parathyroid injury complicating, 488
tracheal collapse complicating, 488
sarcoma, 485
toxic adenoma, 483
heart disease and, 484
secretion, 478
transplantation, 621
Thyroidectomy, 487
bilateral partial lobectomy, 487
postoperative treatment, 487
two-stage operation, 487
Thyroiditis, 475
woody, 476
Thyrotomy, 842
Thyrotoxicosis, 478
Thyroxin, 475, 479
Tibia and fibula together, fracture, 321
dislocation, 376
epiphysis, lower, separation of, 322
fracture, 319. See also *Fractures of tibia*.
osteogenic sarcoma, 246
saber-, 238
Tibial artery, anterior, ligation of, 638
posterior, ligation of, 639
nerve, injuries, 459
tubercle, epiphysitis, 239
separation, 240, 321
Tibiotarsal joint, Volkmann's congenital deformity, 1304
Tic, convulsive, 733
douloureux, 727
Ticks, bites of, 60
Ticks, wood, 61
Tiegel, 878
Tinel and Sauvé, 783
Tinel's sign in nerve regeneration, 433, 445
Tinker and Sutton, 584
Tinnitus aurium, 734
Tissue, division or destruction, by heat, 597
forceps, 500
granulation, 25
regeneration of, 24
repair of, 24
transplantation, 618
Toe, dislocation, 380
great, displacement, 1311
sesamoid of, fracture, 328
hammer-, 1310
hypertrophy, 1289
little, displacement, 1311
Morton's, 1310
pigeon-, 1311
pointed, 1304
prevention, 313
supernumerary, 1289
transplantation of, as substitute for absent finger or thumb, 620
web-, 1289
Toe-nail, ingrowing, 473
Tonga, 167
Tongs, Beasley-Cannaday, *268*
Edmondson fracture, *268*
ice-, used in fractures, 269
Tongue, 819
actinomycosis, 822
bifid, 820
black hairy, 821
burns and scalds, 70
cancer, 823. See also *Carcinoma of tongue*.
chancre, 822
congenital anomalies, 819
dermoid cysts, 823
eczema, 822
epithelioma, 823
erythema, 822
foreign bodies in, 820
frenum, excessive length, 820
geographic, 822
hemorrhage from, treatment, 88
Hutchinson's wart, 822
hypertrophy, 819
leukoma, 821
lymphangioma, 801
mucous cysts, 820
pityriasis, 822
syphilis, 822
wandering rash, 822
wooden, 170, 171
wounds, 820
holding forceps, Collin's, *540*
Tongue-swallowing, 820
Tongue-tie, 820
Tonsillectomy, abscess of lung following, 928
hemorrhage after, treatment, 89
Tonsillitis, 831
acute follicular, 831
chronic, 832
Tonsils, epithelioma, 832
inflammation, 831
palatine, hypertrophy of, 832
sarcoma, 832
syphilis, 832
tuberculosis, 832
tumors, 832
Tooth. See *Teeth*.
Fournier's, 163, *164*
socket hemorrhage, treatment, 88
Toothache, trigeminal neuralgia and, differentiation, 727
Topovaccination of wounds, 54
Torcular tourniquet, 81
Tormina, 22
in acute appendicitis, 1098
Torsion fractures, 256, 257
in arrest of hemorrhage, 83
of penis, 1278
of spermatic cord, 1281
Torticollis, 848
congenital, 848
dermatogenic, 848
in children, 737
myogenic, 848

Torticollis, neurogenic, 848
ocular, 848
reflex, 848
rheumatic, 382
spasmodic, 848
Tourniquet, 81
amputation with, 645
Esmarch's, 81
field, 81
Foulí's, 82
garrote, 81
horseshoe, 82
Momburg's, 82
Petit's, 81
pneumatic, 82
provisional, 81
Samway's, 82
Signorini's, 82
test in purpura hæmorrhagica, 1161
Thomas's, 82
torcular, 81
Truesdale's, 82
Toxemia, gastro-intestinal, gastric tetany in, 1031
in peritonitis, 980
jejunal, in peritonitis, treatment, 984
postoperative, in appendicitis, 1116
Toxic adenoma, 477
of thyroid gland, 483
heart disease and, 484
infection, 125
Toxitabellæ hydrargyri chloridi corrosivi, 135
Toyanes, 579
Trachea, 832
burns, 837
cocain anesthesia, 557
congenital anomalies, 832
fissure and fistula, 832
stenosis, 833
foreign bodies in, 833
fracture, 836
rupture, 874
scabbard, 477
scalds, 837
stricture, 837
traumatic injury, 835
tumors, 841
wounds, open, 838
Tracheal collapse complicating operations on thyroid, 488
tugging in aneurysm, 400
Tracheitis, 833
Tracheloceles, 833
Tracheo-aërocele, 833
Tracheobronchoscopy, 923
Tracheocele, 833
Tracheoscopy, 835
Tracheotomy, 843
high, 843
low, 843
preliminary, 844
tube, *843*
Jackson's, *843*
Traction aneurysm, 398
diverticula of esophagus, 866
Trade bursitis, 387
Transfixion needle, 603
Transfusion, blood-, 90. See also *Blood-transfusion.*
Transplantation, muscle, for facial paralysis, 733
of bone, 619
of fascia, 619
of fat, 618
of joints, 345, 620
of motor fibers, 783
of organs, 621
without vascular anastomosis, 621
of ovary, 621
of parts, 613
of peripheral nerves, 619
of sections of arteries, 619
of veins, 619
of tendon, 619
of testes, 621
of thyroid gland, 621
of tissues, 618
of toe as substitute for absent finger or thumb, 620
Transsacral anesthesia, 576
Transverse fracture, 256
(lateral) sinus, thrombosis, 712
Trapezium, dislocation, 363
Trapezius muscle, paralysis, 384
Traumatic amputation of fingers, *43*
aneurysm, 394, 410
circumscribed, 394
diffused, 394
of scalp, 669
treatment, 46
apoplexy, 706
arteritis, 391
cephalhydrocele, 667
cyanosis, 874, *875*, *876*
delirium, 119
direct, 120
indirect, 120
diaphragmatic hernia, 1204
emphysema, 874
epilepsy complicating skull injuries, 708
hernia, 1167
injury, 36
of abdominal wall, 960
of esophagus, 862
of intestines, 1057
of larynx and trachea, 835
of liver, 1121
of lungs, 926
of lymph-glands, 419
of pancreas, 1151
of spinal cord, 759
of stomach, 1001
neuritis, 432
neuroma, 431
pancreatic cyst, 1151
spinal neurasthenia, 759
spondylitis, 766
stricture of rectum, 1217
tetanus, 149
Traumatism, 36
of breast, 889
of face, 790
of salivary glands, 825
Travois splint, 531
Trematodes, 62
Trench foot, 109
mouth, 818
Trendelenburg, 1250
Trendelenburg's cannula, 843
operation for varicose veins, 416
of pulmonary embolectomy, 98
position, *1216*
inverted, *1220*
test for differentiating coxa vara and congenital dislocation of hip, 373
for varicose veins, 414
Trephine, Galt's, *599*
syndrome, 721
Trephines, 599
Treponema pallidum, 161
pertenue, 167
Triangle, Bryant's, in fracture of neck of femur, 306
Trichiasis, 462
Trichina of chest wall, 884
spiralis, 62
Trichinella, 62
Trichinosis, 62
Trichlor-tertiary-butyl-alcohol, local anesthesia by, 561
Trichobezoar, 1003
in intestine, 1061
in stomach, 1003
Trichocephalus dispar, 62
Trichomonas intestinalis, 65
Trichuris trichiura, 62
Tricresol as disinfectant, 133
Trident hand, 227
Trifacial nerve, lesions, 726
Trigeminal nerve, lesions, 726
neuralgia, 727
Trigger-finger, 1296
Trigone, Scarpa's, ligation of femoral artery in, 637
Trigonitis, 1255
Tri-iodomethane, 138
Trinitrophenol, 137
Triple enema, 504
Trocar, Babcock's, *919*
Frazier's, *711*
Trocar-tube method of thoracostomy, 919
Trocars, *601*, 602
Trochanter, great, separation, 311
lesser, fractures, 311
Trochlear nerve, lesions, 726
Trombone action of ureter, 1225
ureter, 1243
Trophic ulcer, 30
treatment, 33
Tropical abscess of liver, 1122
phagedena, 179
sprue, 819
ulcer, 179
Trotter, 462
Trousseau's sign in gastric tetany, 1032
Truemmerfeld line, 224
Truesdale's tourniquet, 82
Trusses for hernia, 1169
in femoral hernia, 1197
in inguinal hernia, 1185
Tsetse fly, 62
Tube drains, 51
grafts, 611
Tubercle, 158
anatomic, 467
bacillus, 158
Chassaignac's, 80, 627
dissecting porter's, 159
greater, of humerus, fracture, 285
lesser, of humerus, fracture, 285
of Carabelli, 163
subcutaneous, of face, 798
painful, 187
tibial, epiphysitis, 239
separation, 240, 321
Tuberculoma of brain, 717
of spine, 778
Tuberculosis, 158
acute, 935
ascending, of kidney, 1237
caseous, 159
of kidney, 1236
chronic ulcerative, 935
cutis, 467
of face, 795
fibroid, 159
miliary, 159, 935
of bone, 236
of kidney, 1236
of bone, 236
caseous, 236
miliary, 236
treatment, 238
of breast, 894
of chest wall, 882
of face, 794
of hands, 1299
of hip-joint, congenital dislocation and, differentiation, 372
of intestines, 1076
enteroperitoneal, 1077
hyperplastic, 1077
stenosis in, 1069
stricture in, 1066
syphilis and, differentiation, 1077
of kidney, 1236
ascending, 1237
caseous, 1236
miliary, 1236
of lymph-glands, 159
of neck, 855
of parotid, 829
of penis, 1280
of prostate, 1276
of ribs and sternum, 882
of sacro-iliac joint, 772
of seminal vesicles, 1277
of skin, 467
of skull, 682
of spine, 769. See also *Pott's disease.*
of spleen, 1160
of stomach, 1032
of testes, 1284
of tonsils, 832
osseous, of face, 795
pulmonary, 935
anesthesia in, 537
hydrothorax in, 912
intestinal stenosis in, 1069
lipotamponade in, 941
lung abscess and, differentiation, 929
peptic ulcer and, differentiation, 1017
pyopneumothorax in, 913
thrombosis in, 94
results, 159
roentgen rays in, 517

Tuberculosis, seats, 159
treatment, 160
ureteral, 1237
varieties, 159
Tuberculous abscess of bone, chronic, deep, 238
arthritis, 335
bronchial pneumonia, acute, 935
subacute, 935
caries sicca, 237
cystitis, 1256
disease of glands of groin, 425
of neck, 424
empyema, 935
endarteritis, 393
epididymitis, 1284
epiphysitis, 237
gumma, 467
hydrothorax, 935
lymphadenitis, 424
cervical, 424
of neck, 855
lymphangitis, 424
lymph-glands, 159
lymph-nodes, 424
mediastinal lymphadenitis, 93
meningitis, 689
mesenteric lymphadenitis, 425
onychia, 474
osteitis of jaw, 810
osteomyelitis, 237
pericarditis, pericardiotomy for, 947
perinephritis, 1237
periostitis, 237
of jaw, 810
peritonitis, 990
ascites in, 992
Banti's disease and, differentiation, 992
caseous, 991, 992
fibrous, 991, **992**
lymphoglandular, 991
ovarian cysts and, differentiation, 992
wet or ascitic, 991
ulcers, 30, 160
treatment, 33
Tubular adenoma, 203
drainage, 51
Tubulocysts, 222
Tubulodermoids, 220
Tucker's bougie, 869
Tuffier, 941
Tuffier and Hallion, 878
Tuffnell's treatment of aneurysm, 401
Tuholske and Seelig, 1198
Tularemia, 156
Tumba-fly abscess, 59
Tumors, 181
adrenal, 1241
benign, 182
giant-cell, of bones, 252
blood, 37
characteristics, 181
Cohnheim's theory, 184
combinations between, 182
degenerative changes, 182
desmoid, of abdominal wall, 971
diagnosis, 184
epithelial, 203
of face, 801
etiology, 183
fibrocellular, 187
fibroid, of abdominal wall, 971
fibroplastic, 200
giant-cell, 187
of skull, 685
Grawitz, 203, **499**, 1241
growth, 181
histologic classification, 184
malignant, 182
of thyroid gland, 484
metastasis, 182
mixed, 220
of parotid, 829
of testes, 1286
morphology, 182
myeloid, 252
nervous theory, 184
of abdominal wall, 971
of adrenals, 499
of bladder, 1257
of bone, 241
Tumors of bone, benign giant-cell, differential diagnosis, 254
malignant, secondary, 254
nomenclature, 241
predisposing to fractures, 259
of brain, 714. See also *Brain, tumors.*
of bursæ, 390
of carotid gland, 859
of cerebellopontile angle, symptoms, 716
of chest wall, **884**, 885
of face, 798
of heart, 947
of hyoid bone, 850
of intestine, 1079
of joints, 343
of kidney, 1240
of larynx, 841
of liver, 1128
of lung, 936
benign, 936
empyema and, differentiation, 915
malignant, 936
secondary, 937
of lymphatic glands, primary, 427
secondary, 428
of mediastinum, 939
of muscle, 384
of nail-bed, 474
of neck, 857
of pancreas, 1155
of parotid, 829
of penis, 1280
of peripheral nerves, 459
of peritoneum, 996
of pharynx, 830
of pineal body, 498
of pituitary, *493*, 495
of pleura, 917
of rectum, benign epithelial, 1218
of renal pelvis, 1242
of scrotum, 1287
of skull, 684
of small intestine, 1079
of spine, 774
chronic myelitis and, differentiation, 779
echinococcus cysts and, differentiation, 779
extradural, 778
incidence, 775
location, 780
malignant, 774
meningomyelitis and, differentiation, 779
osteo-arthritis and, differentiation, 779
pelvic tumors and, differentiation, 779
point of pressure, 780
removal, 780
syringomyelitis and, differentiation, 779
of spleen, 1164
of stomach, 1033
of tendon sheaths, 385
of testes, 1285, 1286
of tonsils, 832
of trachea, 841
of umbilicus, 959
of upper jaw, 816
parasitic theory, 183
pelvic, spinal tumors and, differentiation, 779
potato-like, of neck, 859
Pott's puffy, 668
primary, 181
prognosis, 184
recurrent, 181
sacrococcygeal, 757
sand, 201
sebaceous, of chest, 884
secondary, 181
varieties, 181
Virchow's theory, 183
Tunica vaginalis, hydrocele of, inguinal hernia and, differentiation, 1184
Tuning-fork test, Weber's, 734
Tunnel anemia, 62
motor amputation, 642
Turpentine stupes, 516
Turtle-shell nails, 429
Twelfth cranial nerve, lesions, 737
Twin monsters, 873
Twine ligature, 596
Twisted bandage, 522
Twists of spine, 759
Tyler and Wohl, 854
Tyloma, 462
Tylosis, 205
linguæ, 821
Typhilitis, 1074
stercoralis, 1074
Typhoid, appendicitis and, differentiation, 1104
delirium, 120
intestinal ulcer in, 1070
hemorrhage from, 1071
perforation of, 1070
osteitis, 235
Typhoidal arthritis, 334
cystitis, 1255
stricture of intestine, 1066
Tyromatosis, 100

Ulcer, 28
Aden, 179
aphthous, 818
callous, treatment, 32
cancroid, 214
classification, 28
Curling's, 69
dental, 820
duodenal, 1012, *1013*
food-ease in, 1013
gastric ulcer and, differentiation, 1016
hemorrhage from, **1015**, 1024
hunger-pain in, 1013
perforated, *978*, *1014*, 1015
acute appendicitis and, differentiation, 1011
peritonitis secondary to, *977*
pyloric occlusion in, 1016
treatment, 1018
exedens, 214
gastric, *1005*, 1006
accessory pocket in, 1007
acute, 1006
and diverticulum, *1028*
carcinoma of stomach secondary to, 1012
chronic, 1006
complications, 1009
corrosion theory, 1006
crater in, 1007
duodenal ulcer and, differentiation, 1016
food-ease in, 1007
gastro-enterostomy for, historical, 1045
hemorrhage from, 1024
incisura in, 1007
neurogenic theory, 1007
organic hour-glass in, 1007
perforated, 1009
abscess secondary to, 1012
acute, 1009
chronic, 1010
subacute, 1010
treatment, 1011
roentgenography, 1007
Sippy treatment, 1008
special operations, 1045
treatment, 1008
with hour-glass stomach, *1029*
gastro-enterostomy, 1019
gouty, 31
healing, 29
intestinal, in typhoid, 1070
hemorrhage from, 1071
perforation of, 1070
tuberculous, 1076
irritable, 29
of anus, 1211
treatment, 32
Jacob's, 214, **471**
jejunal, 1019
perforated, 1020
kissing, 1006
Malabar, 179
marginal, 1019
Marjolin's, 206, **209**, *213*
of mouth, 818
of small intestine, 1069
of stomach. See *Ulcer, gastric.*

Ulcer, pathology, 29
penetrating, 31
peptic, 1005. See also *Peptic ulcer.*
perforating, **31**, 463
treatment, 33
phagedenic, 29
treatment, 32
pressure, treatment, 33
rodent, 214, **471**
of face, 802
scorbutic, 31
spreading, 29
symptoms, 29
syphilitic, 30, *467*
about knee, *163*
treatment, 33
terebrant, 215
treatment, 31
trophic, 30
treatment, 33
tropical, 179
tuberculous, 30, 160
treatment, 33
varicose, **29**, *30*, 414
treatment, **32**, 418
weak, 29
treatment, 32
Yemen, 179
Ulceration, 28
Ulcerative colitis, *1070*
inflammation, 21
Ulcus callosum, 1005, **1006**
penetrans, 1005, **1009**
simplex, 1005
tropicum, 179
Ulna and radius, fracture of both, 297
synostosis, 1290
coronoid process, fracture, 291
dislocations, **358**, 361
head, recurrent, 363
fractures, 290. See also *Fractures of ulna.*
osteogenic sarcoma, 246
Ulnar artery, ligation, 633, **634**
nerve, injuries, 455
rerouting, to front of elbow, *442*
Ultraviolet rays as counterirritant, 516
Umbilical anus, 958
cord, hernia into, **957**
fistula, 958
gastric, 958
fungus, 959
hernia, 1198, *1199*. See also *Hernia, umbilical.*
sinus, 958
stone, 959
Umbilicus, carcinoma, 959
congenital telangiectatic myxosarcoma, 959
cysts, 959
fibrosarcoma, 959
granuloma, 959
inflammation of, in children and adults, 959
in newborn, 959
tumors, 959
epithelial, 959
malignant, 959
Uncinaria, 62
Uncinariasis, 62
Undescended testes, 1281
inguinal testicle and, differentiation, 1183
Unger apparatus for blood-transfusion, *92*
Ungual whitlow, 473
Unguentum iodi, 134
Union by second intention, 29
Unna's paste, 140
Ununited fractures, 273
Urachal dermoids, 220
Urachus, congenital defects, 957
Urea and quinin, hydrochlorid of, local anesthesia by, 560
blood-, test of, for kidney function, 1226
Urea-concentration test of kidney function, 1226
Uremic coma, 118
Ureter, 1243
anastomosis, for exstrophy of bladder, 1249
calculus, 1244
congenital stricture, 1222
contusion, 1243
double, 1222
injuries, 1243
during operation, 1243
operations on, 1244
stricture, 1243
trombone, 1243
action, 1225
wounds, 1243
Ureteral anastomosis, 1244
colic, appendicitis and, differentiation, 1103
from renal calculus, 1230
hematuria, 1223
orifice, 1258
golf-hole, 1256
tuberculosis, 1237
Ureterectomy, 1246
Ureterocolostomy, Coffey's, 1244
Ureterocystostomy, 1244, *1246*
vaginal, *1245*
Uretero-enterostomy, 1242
Ureterolithotomy, 1244
Ureteropyelostomy, 1244
Ureterostomy, 1242, **1244**
Ureterotomy, 1244
Uretero-ureterostomy, van Hook's, 1244
Urethra, 1258
cocain anesthesia, 557
congenital occlusion, 1258
stricture, 1258
contusion, 1259
foreign bodies in, 1259
inflammation, 1260
resection, for stricture, 1270
rupture, 1259
in fracture of pelvis, 302
stones in, 1259
stricture, 1267. See also *Stricture of urethra.*
wounds, 1259
Urethral calculus, 1259
hematuria, 1223
sound, *1268*
introduction, *1270*, *1271*
Urethritis, 1260
complicating gonorrhea in women, treatment, 1266
gonorrheal, 1260. See also *Gonorrhea.*
neisserian, 1260
non-gonorrheal, 1260
simple, 1260
specific, 1260
Urethroplasty, 1270
Urethrotomy, Civiale's, for stricture, 1269
external, for stricture, 1269
without guide, for stricture, 1269
internal, for stricture, 1269
Maisonneuve's, for stricture, 1269
plastic, 1270
Urinary bladder, 1182
hernia of, 1182
changes, 1223
fever, 1271
fistula, 958
complicating urethral stricture, 1271
system in anesthesia, 538
Urination, abnormal frequency, 1224
at night, 1225
painful, 1224
Urine, blood in, 1223
extravasation, in rupture of urethra, 1259
incontinence, 1247
false, 1248
nocturnal, 1247
of overflow, 1248
passive, 1248
pus in, 1224
retention, 1246
complicating urethral stricture, 1270
suppression, 1224
Urobilin test of liver function, 1120
Uronephrosis, 1233
Uta, 179
Uterine hydatid, 188
Uterus, effect of spinal anesthesia upon, 564
Uvula, edema, 830

Vaccine for wounds, 54
gonococcus, 148
staphylococcus, 141
Vaginal enterostomy, *1064*, *1065*
excision of rectal carcinoma, 1220
hematocele, 1284
hernia, 1178
hydrocele, 1282
primary chronic, 1283
lithotomy, 1254
ureterocystostomy, *1245*
Vaginitis, gonorrheal, treatment, 1266
Vagus, injuries, 851
nerve, lesions, 735
Valentine's urethral irrigator, *1256*
Valsalva's treatment of aneurysm, 401
Valves of Heister, 1134
Valvotomy, 946
Valvular incompetency, Trendelenburg's test, 414
stricture of ureter, 1243
Van Buren, 598
Van Buren's sound, *1268*
van den Bergh's test, 1120
van Hook's uretero-ureterostomy, 1244
Vanghetti, 642
Vaquez's disease, 1161
Varices, 194
Varicocele, 194, 418, **1281**
hernia and, differentiation, 1168
inguinal hernia and, differentiation, 1183
lymph, 421
of round ligament, 414
Varicose aneurysm, 396
ulcers, **29**, *30*, 414
treatment, **32**, 418
veins, 414
Babcock's operation, 416, *417*
choice of operation, 418
chronic eczematous areas in, treatment, 418
excision by dissection, 418
Friedel's operation, 417
hemorrhage from, treatment, 418
injection treatment, 415
of leg, 194
Powell's operation, 417
Schede's operation, 416
treatment, 415
Trendelenburg's operation, 416
test, 414
Varicosities, 194, **414**
Variot, 461
Varix, 414
aneurysmal, 396
treatment, 411
arterial, 396
hernia and, differentiation, 1168
lymph-, **420**, 421
saphenous, *1197*
femoral hernia and, differentiation, 1196
inguinal hernia and, differentiation, 1183
Vascular changes in inflammation, 20
Vasoconstrictors, 83
Vasostomy, 1284
Vegetal bronchitis, 833, **924**
Veil, Jackson's, 1068
Vein-stone, 411
Veins, dilatation, 414
dilated, 194
diseases, 411
enlarged, in abdominal wall, *955*
significance, 955
inflammation, 411
infusion, 511
removing blood from, 418
sections of, transplantation, 619
thrombosis, 411
varicose, 414. See also *Varicose veins.*
Veldt sore, 466
Velpeau, 404
Velpeau's bandage, 525
Venectomy, Babcock's, 416, *417*
Venereal disease, fourth, 157
warts, 240, **469**
Venesection, **418**, 515
in war-gas poisoning, 72
Venoclysis, 511
Venoms, snake, **56**, 57
hemorrhagin of, 58
neurotoxin of, 57

Venous anesthesia, regional, 578
anoxemia, 113
hemorrhage, 77
treatment, 88
thrombosis, 99
thrombus, 411
Ventral hernia, 1200
lateral, 1201
median, 1200
Ventricles, lateral, puncture of, in internal hydrocephalus, 699
Ventricular cyst of skull, 671
tap in brain tumors, 719
Ver du Cayor, diseases produced by, 59
macaque, diseases produced by, 59
Vermes, 61
Vermiform appendix, 1095
anomalies of, 1095
inflammation of, 1095
Verminous aneurysm, 395
Verneuil, hydradenitis of, 144
Vernieul's syphilitic bursopathy, *389*
Verruca, **204**, 469
acuminata, 204
carnæ, **197**, 801
digitata, 204
filiformis, 204
necrogenica, 467
of chest, 884
plana, 204
vulgaris, 204
Vertebræ. See also *Spine* and *Spinal cord*.
cervical dislocation, 762
lower cervical, abscess, 772
thoracic, abscess, 772
lumbar, abscess of, 769, 772
lumbosacral, abscess of, 772
osteogenic sarcoma, 246
prominens, 739
upper cervical, abscess, 772
thoracic, abscess, 772
Vertebral arteries, digital compression, 80
ligation, 630
bodies, compression fracture, 764
crushing fracture, 764
epiphysitis, 240
Vertical imbrication for umbilical hernia, 1199, *1200*
Vertigo complicating skull injuries, 708
Vesical. See also *Bladder*.
hematuria, 1223
hemorrhage, treatment, 89
pyuria, 1224
Vesication, 67, 516
Vesicles, 21
seminal, calculus of, 1277
diseases, 1276
excision, 1277
incision, 1277
inflammation, 1276
tuberculosis, 1277
Vesicular inflammation, 21
Vesiculectomy, 1277
Vesiculitis, acute, 1276
chronic, 1276
seminal, chronic, gonorrheal, 1265
gonorrheal, treatment of, 1264
Vesiculotomy, 1277
Vestibular nerve, lesions, 734
Viability of intestines, 1176
determination, 1060
Vibrion septique, 148
Vicious circle following gastro-enterostomy, 1021
operations for, historical, 1045
Vienna treatment for foreign bodies in intestine, 1062
in stomach, 1004
Villata, 206
Villou, 927
Vincent, 175
Vincent's angina, 818
Vinson, 864, 866, 869
Vioform, 138
Virchow, 758, 1075
Virchow's fissural theory of angioma, 194
theory of tumors, 183
Viscera forceps, Babcock's, *1067*
for appendectomy, *1108*
injuries, closed, 961
pleurectomy, 921
Viscera, pleurotomy, 922
reflex arc, 954
Vitello-intestinal duct, anomalies of, 957
fistula, 958
Volkmann, 858, 930, 1294
Volkmann's congenital deformity of tibiotarsal joint, 1304
contracture, 105, 289, 433, **1294**
complicating fractures, 263
retractors, 601
supramalleolar deformity, 1304
Volsellum forceps, *599*, 600
Volvulus, 1064
of stomach, 1028
Vomiting, 998, 1032
cyclical, 1033
fecal, in strangulated hernia, 1174
in intestinal obstruction, 1059
in tumors of brain, 715
periodical, 1033
stercoraceous, 1059
in strangulated hernia, 1174
von Bechterew, 767
von Bruns, 231
von Eiselsberg, 477, 1045
von Gies' joints, 339
von Graefe's sign in exophthalmic goiter, 480
von Hacker, 1045
von Hacker's gastro-enterostomy, 1051
operation, 1015
von Jaksch's anemia, 1160
von Recklinghausen's disease, **228**, 459
of chest, 884
of neck, 858
of scalp, 669
von Redwitz, 146
von Winiwarter, 1045
Voronof, 621
Vulvovaginitis, gonorrheal, 1267

Wachselmann, 508
Wagner-Jauregg, 166
Wallerian degeneration, 431
Walters, 513, 1130
Walton, 261
Wandering heart, 943
kidney, 1227
rash on tongue, 822
spleen, 1158
War wounds of chest, 879
War-gas poisoning, 71
Wardrop, 403, 533
Wardrop's operation for aneurysm, *403*
Warren, 892
Warren's incision in breast cancer, *905*
Warren-Thomas breast incision, *890*
Warts, 204, **469**
anatomical, 159
butcher's, 467
dissecting porter's, 158, 467
fleshy, 801
horns, 205, 798
Hutchinson's, on tongue, 822
of chest, 888
sarcomatous, cutaneous soft, 801
venereal, 204, 469
Wassermann, 746
reaction in syphilis, 166
Water, hot, disinfection by, 130
Water-glass bandage, 531
Waterman's bottom, 390
Watson, 487
Waugh's operation for cecum mobile and ptosis of ascending colon, *1089*
for prolapse of ascending colon, *1088*
Wax, Horsley's, 133
Weak ulcer, 29
treatment, 32
Weakness of anterior abdominal wall, 963
Weaver's bottom, 390
Web-fingers, 1289, **1292**
Web-toes, 1289
Weber's tuning-fork test, 734
Weed, 509, 512
Wegenforth, 509
Weinberg, 508
Weir's appendicostomy, 1090
Welch, 141
Wells, 533, 548
Wen, 220, **468**
of scalp, 668
Wenckebach, 946
Werelius, 946
Werlhof's morbus maculosus, 1162
Wet brain, 121
dressing for wounds, 49
solutions used, 50
tuberculous peritonitis, 991
Wharton's duct, 825
Wheal, 37
Wheelhouse's operation for urethral stricture, 1269
Whip-worm, 62
Whipple, Haden, and Orr, 1058
White bile in gall-bladder, 1131
gangrene, 104
spots on nails, 473
swelling, 335
pseudo-, 339
Whitehead's operation for cancer of tongue, 824
for hemorrhoids, 1213
varnish, 139
Whitlow, 1297
melanotic, 474
ungual, 473
Whitman's operation for coxa vara, 1301
for ununited fracture of neck of femur, 308
treatment of fracture of neck of femur, 307
Widal's hemoclastic crisis in hepatic disease, 1120
Willem, 46
Willems' treatment of acute arthritis, 333
of open dislocations, 351
Wilms, 932, 940, 1124
Wilms' method of suturing tendons, *385*
operation, 941
Windlass, Spanish, 81
Winged scapula, 353, 448, **1289**
Winslow, 1204
Wire splints, 532
Wiring of fractures, 270
Withering cancer of breast, 903
scirrhus, 208
Witzel, 1045
Witzel's gastrostomy, 1047
jejunostomy, 1048
Wohl, 170, 177
Wohl and Tyler, 854
Wohlgemuth's test in pancreatic cysts, 1154
Wolfe's method of skin-grafting, 617
Wolfe-Krause method of skin-grafting, 617
Wolff, 509
Wolfenden's position, 841
Wolff's bottles, *921*
Wölfler, 1045
Wölfler's gastro-enterostomy, 1049
intestinal suture, *1087*
operation combined with entero-enterostomy, *1026*
Wood lice, bites of, 60
tick, 61
in Rocky Mountain fever, 61
paralysis, 61
season, 61
Wooden tongue, 170, 171
Woody phlegmon, 854
thyroiditis, 476
Woodyat, 123
Wool-sorter's disease, 152
Work, resuming, after operation, 592
Worm aneurysm, 395
Worms, 61
guinea-, 62
pin-, 62
round-, 61
seat-, 62
screw, diseases produced by, 59
thread-, 62
whip-, 62
Wounds, 36
anesthetic powders for, 47
antiseptic poultice for, 49
powders for, 48
solutions for, 50

Wounds, aseptic, 36
powders for, 47
bichlorid solution as wet or moist dressing for, 50
bismuth powders for, 48
bromin solution as wet dressing for, 50
bullet, treatment, 45
Carrel-Dakin treatment, 53
closed, 36
closure, 41
after sloughing, 41
delayed primary, 41
immediate, 41
primary, 41
secondary, 41
complicated, 36
contused, 36, 40
treatment, 41
cresol solutions as wet or moist dressings for, 50
crushing, 42
secondary infection in, treatment, 43
treatment, 38
Dakin's solution for, 53
delayed healing, 54
dichloramin-T for, 53
dilute alcoholic solution as wet dressing for, 51
dissection, 36
drainage, 51
dry dressing, 47
exposure to air, 47
gunshot, 36, 40, 44
Carrel-Dakin treatment, 54
of abdomen, 963
of bone, predisposing to fracture, 259
of face, 791
of joints, treatment, 357
of neck, 850
treatment, 45
healing, 39
by first intention, 39
by granulation, 38
by organization of blood-clot, 39
by second intention, 25, 39
by third intention, 39
delayed, 42
epithelization, 39
prevention, 42
support in, 42
under scab, 39
Wounds, incised, 36, 38
after-treatment, 39
treatment, 38
infection of, 54
involving outer layer of skin, 38
iodin solution as wet dressing for, 50
iodoform for, 48
lacerated, 36, 40
treatment, 41
mercuric chlorid as wet or moist dressing for, 50
moist dressing for, 49
multivisceral, 963
open, 36
of larynx and trachea, 838
penetrating, 36
of bladder, 1251
perforating, 36
permanganate of potash as wet dressing for, 50
phenol solutions as wet or moist dressings for, 50
poisoned, 36
powder dressing, 47
primary closure, 54
protective powders for, 47
punctured, 36, 43
treatment, 44
secondary complications, 54
sedative solutions for, 50
septic, 36
simple, 36
stab, 43
treatment, 44
subcutaneous, 36
sublimate solution as wet or moist dressing for, 50
suture, 41
delayed primary, 41
secondary, 41
topovaccination of, 54
treatment, varieties, 47
univisceral, 963
vaccines for, 54
visceral, closed, 961
wet dressing for, solutions used, 50
Wren and Archibald, 90
Wright's hemostatic, 88
Wrist, amputation, 7651
disarticulation, 651
dislocations, 363
extensor paralysis, Jones' operation, 386
Wrist, extensor paralysis, Jones' operation, Stiles' modification, 386
Stöffel's operation, 387
fracture, 298
Madelung's deformity, 1291
semilunar bone, dislocation, 362
septic arthritis, 1299
snapped, navicular, 298
Wrist-drop, *506*
Wrist-joint, arthrotomy, 343
fracture, optimum position for ankylosis, 265
supernumerary bones, 1290
Wry-neck, 848
Wyeth, 645
Wyeth's pins, *645*

Xanthochromia of cerebrospinal fluid, 746
Xeroform, 138, 139
Xerostomia, 829
Xiphopagotomy, 873
Xiphopagus, 873
X-legs, 1302
x-Ray. See *Roentgen ray.*
Xylol bromid, effects of, 71

Y-bandage, 526
Y-fracture of humerus, 288
Yankauer, 929
Yaws, 166
crab, 167
Yellowish cerebrospinal fluid, 746
Yemen ulcer, 179
Young, 1095, 1284, 1286
Yperite, effects of, 71

Z method of tenoplasty, *385*
Z plasty, Pieri's, 1295
Zinc chlorid in cancer, 216
stearate, inhalation of, 924
Zinc-oxid adhesive plaster in fractures, 266
Zona dermatica, 747, 748
epithelioserosa, 747, 748
Zuckergussleber, 995, 1127
Zuckerkandl's organ, 498
Zygoma, fracture, 275

P9-CUX-606